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HOW DOES EMOTION INFLUENCE
COLLABORATION? - AN AGENT BASED
SIMULATION OF THE DYNAMIC OF
CONFRONTATION

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EXECUTIVE SUMMARY

This research aims to investigate the dynamics of interaction and conflicts among agents using drama theory in Citarum river basin problems. Citarum River basin is a region in Java Island, Indonesia, with 6,080 km² area crossing two provinces, *i.e.*, West Java, and Jakarta. Citarum River is one of the strategic rivers in Indonesia. Almost everyone along Citarum River utilize its water to support their life; *e.g.* for drinking water, industry, agriculture, power generation, flood control and recreation object. In the past Citarum River can perform these functions well, but those conditions have completely change. There are several causes of this change. First is the population explosion that led to an increase in illegal lodging and deforestation in the upper stream region. Second is household waste disposal into the river. Along the Citarum River there are \pm 8 million residents who approximately dispose 200 tons of household wastes per month into Citarum River. Third is the industrial waste disposal into the river. In the Citarum river basin there are approximately 1000 industries that use surface water, as well as producing industrial waste. Many of industries do not perform waste treatment before throwing them away into Citarum River. As a result, floods always occur during the rainy season due to sedimentation at Citarum river downstream region, and the increasing number of barren land. The flood and the dirty river water have also caused many kinds of diseases suffered by the community along the Citarum River.

There are hundreds of agents involved in the conflict in the Citarum River Basin. These agents consist of central government agencies, provincial government agencies, city agencies / counties and villages, state-owned enterprises, NGOs at the regional level and NGOs at local level. There are many programs and proposals that have been produced through the repeated interactions and negotiations among these agents such as Citarum Bergetar program in 2001 and Integrated Water Resources Management (IWRM) program in 2008. However, since each agent has different interests, these programs and proposals cannot produce a significant impact on the improvement of Citarum River Basin conditions. Besides that, agent's emotion and learning also play important role in the interactions among agents, and affect the resolution of the conflict.

To accomplish the research's aim, an agent-based model of confrontation based on drama theory, combined with emotional-state model (PAD) and learning models was constructed. The proposed model is able to describe negotiation process as repeated interactions among agents, in which the possible conflict resolutions are truly affected by agent's emotion and learning process. During the conflict phase the model is able to describe two types of dilemma of conflict *i.e.* persuasion and rejection dilemma. After the conflict has resolved, the model is able to describe the emergence of the dilemma of collaboration *i.e.* trust dilemma, among the agents.

In order to obtain necessary inputs for the constructed model, field observations and focus group discussions with stakeholders in Citarum river basin conflict were conducted. Stakeholders involved in this process come from government, NGOs, community members, public enterprises, and business. Through this process description of the current condition of Citarum river basin conflict is obtained. Based on the obtained data the chronological history of Citarum river basin conflict can be captured.

In order to test model's robustness toward the dynamics of common reference frame and the emergence of new options the conflict's chronological history is divided into two different milestones (resulting two scenarios). By considering the completeness of the data, the first milestone is set at 2008 and the second milestone is set at 2009. Each scenario consists of two common reference frames; i.e., the common reference frame before the milestone and the common reference frame after the milestone. For instance, the first scenario consists of common reference frame before 2008 and common reference frame after 2008. By using the two common reference frames in each scenario, agent's efforts to reduce the dilemmas can be identified. In addition, changes of agent's emotion toward the other agents can also be obtained.

Experiments are then conducted to test the model sensitivity, validity, feasibility, and to infer recommendations for agents in the real world. The meaning of feasible in this study is that the proposed models can be used to assist agents in the real world in facing conflict situation. Feasible and valid have overlapping meanings. Generally, valid means something that can be accepted as legitimately and logically (WrodNet Search 3.1; Wikitionary.org) while; feasible means something that is capable of being done with means at hand and circumstances as they are (WrodNet Search 3.1; Wikitionary.org). Not all valid solutions /answers are feasible to be used. But all answers/solutions that are produced by something that is feasible must be able to satisfy all constraint (valid answer) (Wikipedia.org). With this understanding, the proposed model will be considered as feasible to be used if the model can produce valid solutions in all cases tested in the experiment.

The first experiment aims to test model's sensitivity. The number of iterations required to eliminate confrontation dilemmas and the amount of trust dilemma that appears become the main parameters to test the sensitivity of the model. The sensitivity analyses of the proposed model shows that the number of iterations required to eliminate the confrontation dilemmas and the number of trust dilemma that arise are significantly lower if all agents have positive emotions towards other agents. The sensitivity analysis also concludes that the model is robust to the initial common reference frame so that the result will be consistent even if the model is used for other conflict situation.

The second experiment and the third experiment aim to test model's validity and feasibility. The validity analysis results show that the proposed model is valid to

describe the trend of agent's emotion and the majority of agent's position that may appear during the conflict. The validity analysis results also show that the proposed model is robust against initial common reference frame. This means that the model will also valid to describe the trend of agent's emotion and the majority of agent's position that may appear in other conflict situation. Since the model validity applies generally, the model can be considered as feasible to help real world agents to anticipate the dynamics of agent's emotion trends and the majority of agent's positions that may occur in the real world.

By doing experiments with the proposed model it can be concluded that in order to achieve resolution that can help to improve the condition of the Citarum River it is suggested that the agents in the real world should use positive emotions in negotiation with other agents. Moreover, the use of positive emotions accelerates the achievement of conflict resolution, and reduces the possibility of the emergence of trust dilemma.

INTRODUCTION

Background

A conflict, from mere difference of opinion to deadly confrontations, is inevitable in human life (Obeidi, Kilgour, & Hipel, 2009). Different from natural phenomena, social phenomena involve human, organization, country, and company which may behave according their own interests. Social phenomena involve interactive situation, in which many parties are related and interdependent. In such situation, result gained by a person will depend on action from other persons. Therefore, human interaction always involves conflict and collaboration. The conflict occurs due to the different interests owned by each person while the collaboration is needed to achieve a desired outcome in the best way possible for all parties. As an effort to resolve conflict, negotiation becomes a very common process in everyday life. This is why the negotiation process studied in various scientific fields such as economy, political science, psychology, organizational behavior, decision sciences, operations research and mathematics (Sycara & Dai, 2010).

In general, researches from social sciences fields related to the negotiations process aim to understand the factors involved in a negotiation (descriptive) (Martinovski, 2010; Koeszegi & Vetschera, 2010; Albin & Druckman, 2010) while, research from economics and mathematics fields aim to formalize the negotiation process so that the negotiations can be achieve optimal results (prescriptive). In general, most models that have been produced are oversimplified versions of reality (Sycara & Dai, 2010). They generally make the assumptions that the negotiation process is well structured where the negotiation actions occur and result in agreement or opting out of the negotiation. In addition, almost all of current research considers negotiation or conflict as a onetime event (Sycara & Dai, 2010).

However, the conflict situations in the real world are generally more complex than the assumptions used in current studies. Negotiation in the real world (except in its most simple form) has the followings characteristics *i.e.*:

- a) Decentralized (Sycara & Dai, 2010), parties in a negotiation cans have different frames and strategy in seeking resolution of conflict.
- b) Involve communication among parties (Sycara & Dai, 2010). Decisions of negotiators are interlinked through communication processes that involve many different levels (Koeszegi & Vetschera, 2010).
- c) Involve incomplete information (Sycara & Dai, 2010), for example, a party cannot know for certain the utilities from the other parties.
- d) In many cases, negotiation process in the real world involves repeated interaction with no well-structured sequences (Sycara & Dai, 2010).
- e) Negotiation process involves emotions of each party. Emotion is an important device in structuring goals, values and preferences

(Martinovski, 2010) and affects communication (Koeszegi & Vetschera, 2010) in a negotiation.

Through the above review, gaps between current research on conflict and negotiation and the situation in the real world can be identified. To overcome the existing gaps, an approach that is able to describe the negotiations as a decentralized process, involving incomplete information and communication processes that occur iteratively and involving emotions is needed. Computer simulation is one of the alternative approaches to fill the gap that currently occurs. There are several natures of a computer simulation that can help researchers to model a negotiation process, namely:

- a) The nature of programming language that is more expressive than verbal language and less abstract than mathematical equation (Srblijinović & Škunca, 2003), enable researcher to model both quantitative and qualitative theories (Gilbert & Terna, 2000).
- b) Using computer simulation it is easier to model decentralized processes that involve bounded rational agents (Srblijinović & Škunca, 2003).
- c) Within a computer simulation there are no difficulties to model repeated interaction with no well-structured sequences.

This study aims to construct an agent-based simulation of the dynamics of negotiation based on drama theory frame-work. Agents in the constructed simulation are equipped with emotions and ability to learn. The agent-based simulation is chosen because it can minimize the number of simplifications used by its ability to fully represents individuals and model bounded rational behavior while, drama theory is chosen because, it proposes an episodic model whereby situations unfold. By constructing an agent-based simulation to model conflict and collaboration it is expected that the possible evolution of the conflict can be observed and suggestions to agents in the real world in order to achieve the desired futures can be proposed.

This research is a further development of a series of studies that have been carried out since 2007. In 2007, an agent-based simulation model of the negotiation process based on drama theory framework has been constructed (Putro, Siallagan, & Novani, 2007). The model that has been constructed integrates PAD emotional model into negotiation protocol among agents. This model was able to describe the dynamics confrontation dilemmas due to the variations agent's emotion during the negotiation process. In 2008, this model was developed by integrating trust dilemma using norm game mechanism (Putro U. , Siallagan, Novani, & Utomo, 2008). The model was further developed in 2009 by integrating learning mechanisms (Putro, Hermawan, Siallagan, Novani, & Utomo, 2010). The focus of current research is to enhance the existing model so that it can describe the dynamics of confrontation dilemmas (rejection and persuasion) and collaboration dilemmas (trust) without involving the norm game

mechanism. The second focus in this research is to study the feasibility of the constructed model in representing the dynamics of conflict in the real world.

Objectives

In this study, there are several objectives to be achieved, namely:

1. To investigate the dynamics of interaction and conflicts among agents using drama theory in Citarum river basin problems.
2. To develop agent-based simulation model of the dynamic of confrontation based on interaction among autonomous agents, who have different interests and act based on their emotion. The drama theory will be used as a framework of the negotiation process.
3. To develop agent's learning procedure in order to accommodate their learning processes under dynamic situation and the changes of their emotion based on previous experience.
4. To study the feasibility of simulation results based on qualitative research in Citarum river basin conflict.
5. To obtain suggestions for encouraging greater collaboration in Citarum River Basin

To meet these objectives there are several research questions that need to be answered in this research, i.e;

1. How is the development of conflict situations in the Citarum River Basin?
2. How to model negotiation process among autonomous agents who have emotional state in Citarum river basin conflict?
3. How to combine emotional model and learning algorithm into negotiation process in Citarum river basin conflict?
4. What kinds of suggestions (e.g. behavior or policy implication) that can be inferred from the simulation results?
5. How is the feasibility of simulation results compare to the qualitative study result in Citarum river basin conflict?

THEORETICAL BACKGROUND

This chapter discusses the theoretical foundations relating to the construction of the model in this study. The discussion in this chapter is divided into three sections, first section discusses the drama theory, the second section discusses the agent-based simulation and the third section discusses the emotions in negotiations. The first section discusses the definition and the understanding of drama theory, the drama theory perspective on the dynamics of a conflict and why drama theory is considered suitable as a foundation of the proposed model in this study. The second section discusses the understanding of agent-based simulation, the elements of agent-based simulation and why agent-based simulation model is suitable to construct a model of conflict. The third section discusses the role of emotions in a negotiation of conflict, the PAD emotion model and why this model is considered suitable to be used in this research.

The Drama Theory

Drama theory was proposed (Howard, Bennett, Bryant, & Bradley, 1992) and developed as a generalization of game theory (Howard, Drama theory and its relation to game theory. Part 1: Dramatic resolution vs rational solution, 1994; Howard, Drama theory and its relation to game theory Part 2: Formal Model of the Resolution Process, 1994).

In any collaboration each involving agent will demand a solution that suits them: these solutions may be compatible (the situation in which collaboration is achieved) or they may not (the situation in which conflicts emerges). In the latter case, drama theory is able to anticipate the specific pressures – in the form of dilemmas – felt by each agent, and to describe how these pressures might be changed. To identify dilemmas that may occur, drama theory posits that each autonomous agent in a situation proposes a particular solution (called as 'position') in terms of what it and others should do. It presses for this outcome by indicating the unilateral action (its 'fallback') that it will take if the proposed solution is not agreed. The so-called 'threatened future' is the outcome that will occur if each agent carries out their fallback actions.

According to drama theory perspective, the dynamics in a conflict can be analogized as episodes of a drama that is illustrated described in Figure 1.

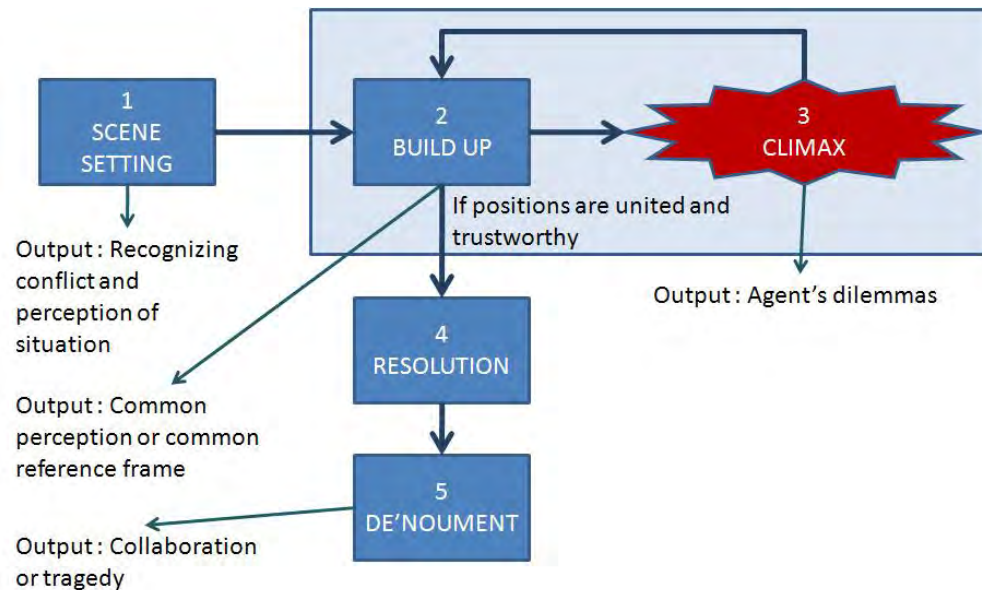


Figure 1 Episode in drama theory

The scene setting is the stage where agents noticed that there are incompatibilities between its positions and other agent's positions. At this stage, each agent has its own information and perspective regarding the conflict. Difference information and perspective led to different understandings (frames) owned by each agent (Bryant, Drama Theory: Dispelling the Myths, 2007).

Build up is a stage where each agent declares its positions and fall back actions to other agents. Through this stage, all agents have the same understanding about the conflict that was happening (common reference frame) (Bryant, Drama Theory: Dispelling the Myths, 2007).

During the climax stage, dilemmas will arise and hamper the resolution process (Bryant, The six dilemma of collaboration : inter-organisational relationship as drama, 2003). At this stage drama theory asserts that each agent will use emotion and reason as it attempts to 'pull' other agent's position towards its own position (Bryant, Drama Theory: Dispelling the Myths, 2007). There are two kinds of dilemmas that may occur during climax stage:

1) Confrontation dilemmas

These dilemmas occur when agents are still don't have common position. There are four kinds of confrontation dilemmas, namely:

- a) Persuasion dilemma: Agent 1 has persuasion dilemma with respect to agent 2, if agent 1 cannot persuade agent 2 to accept agent 1's position because agent 2 prefers threatened future than agent 1's position (Bryant, The Plot Thickens: Understanding Interaction Through the Metaphor of Drama, 1997).

- b) Rejection dilemma: Agent 1 has rejection dilemma with respect to agent 2, if agent 1's rejection of agent 2's position is not credible according to agent 2, because agent 2 knows that agent 1 prefers agent 2's position than the threat (Bryant, *The Plot Thickens: Understanding Interaction Through the Metaphor of Drama*, 1997).
 - c) Threat dilemma: Agent 1 has threat dilemma with respect to agent 2, if agent 1's threat is not credible according to agent 2, because agent 2 knows that agent 1 prefers another scenario than the threat (Bryant, *The Plot Thickens: Understanding Interaction Through the Metaphor of Drama*, 1997).
 - d) Positioning dilemma: Agent 1 has positioning dilemma with respect to agent 2, if party 1 cannot persuade agent 2 to accept its position because it prefers agent 2's position than agent own position (Bryant, *The Plot Thickens: Understanding Interaction Through the Metaphor of Drama*, 1997).
- 2) Collaboration Dilemmas
- If the confrontation dilemmas are successfully eliminated, then agents will have a common position but, they could still face collaboration dilemmas, *i.e.* there are still possibilities for agents to not to trust one another commitments over the common position. There are two kinds of collaboration dilemmas, namely:
- a) Cooperation dilemma: Agent 1 has cooperation dilemma with respect to agent 2, if agent 1 has incentives not to commit with the common position, because another scenario is better than the common position (Bryant, *The Plot Thickens: Understanding Interaction Through the Metaphor of Drama*, 1997).
 - b) Trust dilemma: Agent 1 has trust dilemma with respect to agent 2, if agent 1 cannot believe that agent 2 will commit with the common position, because agent 1 knows that there is another scenario preferred by agent 2 than the common position (Bryant, *The Plot Thickens: Understanding Interaction Through the Metaphor of Drama*, 1997).

At the resolution stage there are two possible conditions that can be faced by the agents. The first condition is called a crisis, in which agents publicly undertake to carry out their fall back actions. The second condition is called commitment, in which agents publicly undertake to carry out their shared agreement (Bryant, *Drama Theory: Dispelling the Myths*, 2007).

At the stage De'nouement agents implement the resolutions obtained in the resolution stage. At this stage there are two conditions that may occur. The first condition is called a conflict, in which agents implement committed fall back actions or decide to flunk their fall back actions. The second condition is called a cooperation, in which agents implement agreed actions or decide to cheat (Bryant, *Drama Theory: Dispelling the Myths*, 2007).

From the discussion in this section it can be concluded that drama theory generally aims to understand how a situation unfolds under the internal pressures that are brought by agents. It primarily focuses on dilemma or paradox arising from rational goal seeking behavior. As a development from game theory, drama theory (Howard, Bennett, Bryant, & Bradley, 1992; Bryant, Using drama theory: concepts and cases, 1997) reflects an increasing interest in how a conflict might change, rather than just the analysis of fixed games. Different from Game Theory, Drama Theory focuses on how the conflict that happens during pre-play game may change due to agent's efforts to eliminate dilemmas using positive or negative emotions therefore, Drama theory can explain how an irrational behavior arises. With these reasons, drama theory is considered to be suitable to model the dynamics of conflict that involves emotion and learning.

Agent-Based Simulation

Generally, the term to *simulate* can be defined to imitate a process by another process (Hartmann, 1996). Therefore, simulation can be defined as driving a model of a system with suitable inputs and observing the corresponding outputs (Axelrod R. , 2003). What is an agent based simulation? An Agent based simulation can be defined as a simulation of a system that consists of a number of software individuals, called agents. In this simulation, agents can interact with each other and with their environment (Gilbert N. , 2004; Smith & Conrey, 2007). In agent based model, an agent can have one to one relationship with an actor in the real world while, interactions among agents can likewise correspond to the interactions between real world actors (Gilbert N. , 2004).

In agent based simulation, agents are programmed to have the following characteristics:

- a) *Discrete*: An agent is self contained individual with identifiable boundaries (Smith & Conrey, 2007).
- b) *Interdependent*: Agents live in an environment that is inhabited other agents (Smith & Conrey, 2007). The behavior of an agent will change some aspect of the environment which in turn affects the behavior of other agents (Macy & Willer, 2002).
- c) *Active*: Each agent has their own rules and strategies to interact with other agents and the environment (Jennings, Faratin, Johnson, Norman, O'Brien, & Wiegand, 1996; Epstein J. M., 1999; Smith & Conrey, 2007).
- d) *Limited information*: Each agent has only limited information. They are only able to gather information from their local environment (for example: neighboring agents) (Epstein J. M., 1999; Smith & Conrey, 2007).
- e) *Autonomous*: An agent has its own internal goals and is self directed in choosing behaviors to pursue those goals (Jennings, Faratin, Johnson, Norman, O'Brien, & Wiegand, 1996; Epstein J. M., 1999; Macy & Willer, 2002; Smith & Conrey, 2007).

- f) *Agent follow simple rule*: Agents are assumed to gather information and generate behaviors by relatively simple rules (Macy & Willer, 2002; Smith & Conrey, 2007).
- g) *Adaptation*: Some models assume that agent can modify their rules based on agent's experience (Jennings, Faratin, Johnson, Norman, O'Brien, & Wiegand, 1996; Macy & Willer, 2002; Smith & Conrey, 2007).

The first advantage of agent based simulation lays on its communicative ability. Basically, any researcher who tries to make a projection or imagining a social dynamics is running a model (Epstein J. M., 2008). The most important thing for a researcher is, whether he/she is able to make an explicit model or not (Epstein J. M., 2008). Before simulations method become famous, there are two general ways to specify a model namely, verbal representation and mathematical equation. The difficulty with verbal representation is that is it hard for the researcher and the reader to determine precisely the implication of the ideas being put forward (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000). Mathematical equations can communicate a model with much more precision than the verbal representation. But, this kind of representation also has weakness. Many of the mathematical equations are too complicated to be analytically tractable (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000). The common solution is to make simplifications (for example, by ignoring the heterogeneity of the actual population an only looking for the mean behavior) until the equations become solvable (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000; Axtell R. L., 2003). Unfortunately, sometimes these assumptions are implausible and can make the resulted theories seriously misleading (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000). These problems also occur in conflict and negotiation researches (Sycara & Dai, 2010).

Agent based simulation can minimize the number of simplifications used by its ability to fully represents individuals (Axtell R. L., 2003) and model bounded rational behavior (Axelrod R. , 2003). Besides, there is no difficulty to represent non linear interaction within a computer simulation (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000). In short, agent based simulation can offer alternative solution when mathematical equation is intractable (Axelrod R. , 2005).

Many social phenomena require multidisciplinary study (Epstein J. M., 1999; Axelrod R. , 2005). The nature of programming language that is more expressive than verbal language and less abstract than mathematical equation (Srblićinović & Škunca, 2003), enable researcher to model both quantitative and qualitative theories (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000). Therefore, agent based simulation can facilitate the collaboration among disciplines (Axelrod R. , 2005).

Another advantage of agent based simulation is that it places much lower demands on data. It is very difficult to acquire appropriate data to understand the dynamics within the society (Gilbert, 2004). Qualitative data from interviews, records and observations can describe effectively the emergence institution from individual actions. But, due the nature of the data most analysis inevitably remains somewhat impressionistic (Gilbert N. , 2004; Johnson & Onwuegbuzie, 2004; Johnson & Christensen, 2007). Studies based on quantitative data can provide more precision (Gilbert N. , 2004; Johnson & Onwuegbuzie, 2004). But, most survey data treats peoples as isolated atom and pay little attention to the interactions among people (Gilbert N. , 2004). Another weakness of survey method is that they come from measurements made at one moment of time (Gilbert N. , 2004). This way, individual changes and effect of these changes are invisible for the analysis (Gilbert N. , 2004; Zawawi, 2007).

Agents based approach start with the deductive perspective by constructing simulation correspond to one's theory about society (Gilbert N. , 2004). In constructing a simulation, input data can be calibrated from whatever data is available and then used to derive testable propositions and relationships (Gilbert N. , 2004). Data generated by the simulation runs then summarized, so it can be tested against the real data (inductive part of agent based approach) (Carley, 1999; Gilbert N. , 2004). This way, agent based simulation approach places much lower demands on the data while, the models can truly reflect the complex nature of the society (Epstein J. M., 1999; Gilbert N. , 2004).

Of course agent based model approach also has weaknesses. Most agent based model and the theory on which they are based, are stochastic (they are based in part on random chance) (Carley, 1999; Gilbert N. , 2004). Its means that it will be difficult to determine whether, the observed pattern is the general pattern or just anomalies.

Besides, many different agent-based models can show the same emergence pattern. Therefore, similarity between the pattern in the real world and one that emerges from the model is not sufficient to conclude that, mechanism used in the model is the same mechanism that applies in the real world (Gilbert N. , 2004).

By considering the benefits and advantages of agent-based simulation that are described in this section, this approach is considered to be appropriate to build a model of conflict that involves emotion and learning.

Agent-Based Simulation Research Metodology

Until now, there is no standard methodology to create an agent based simulation (Gilbert, 2004). But, there are several steps that usually carried out to create a good agent based simulation. The first step is to identify the target system clearly. A target system is a real phenomenon that wants to be understood

better (Gilbert N. , Agent-Based Models, 2008). It is important to refine the general research topic into specific research objectives (Gilbert N. , 2004). After the research objectives are defined, the body of theory regarding the target system must be gathered. Theory about the dynamics and process about social phenomena are better than static or equilibrium relationship (Gilbert N. , 2004). By the way any theories are better than none (Gilbert N. , 2004). Finally, the scope of the model must be defined. In this process, all assumptions in the model should be specified very clearly. Simulation usually begins from a simple model that is easy to implement (Gilbert N. , 2004).

In the second step, the simulation design is started. In this step, first all types of objects in the simulation are defined (Gilbert N. , 2004). Usually, there will be two type of objects in the simulation namely; a) agents and b) environment. If, one object consists of several sub-objects, these objects should be arranged into a hierarchical class (Gilbert N. , 2004). After that, attributes for all objects are specified. An attributes is a characteristic or feature of an objects (Gilbert N. , 2004; Gilbert N. , Agent-Based Models, 2008). An attribute can serve as object's identity or, varies over time (Gilbert N. , 2004).

The third step is to design interactions among objects. First, all possible actions that can be carried out by each object are listed (Gilbert, 2004). After that, rules that are used by an object to execute each action need to be specified. The simplest technique to design object rules is the production system. In the production system technique, an object should be equipped with (Gilbert & Terna, 2000; Gilbert, 2008):

1. *A set of rules of behavior*: Rules that determine what the object will do. One or more rules from the set can be selected depending on the current state of the object.
2. *A working memory*: Variables that store object's current state.
3. *A rule interpreter*: A programming code that uses working memory to select which action should be activated.
4. *An input process*: A programming code that collects messages and perception from the environment and stores them in the working memory.
5. *An output process*: A programming code that transmit messages to the environment.

After all possible actions are specified, we should also consider when each action happened. In most models, the simulations run using discrete time steps. There are three issues that need to be considered when designing agent based simulation using discrete time step (Gilbert N. , Agent-Based Models, 2008):

- 1) *Synchronicity*: the arrangements of action sequence. With an ordinary computer agents cannot engage in action simultaneously therefore, the

simulation output will determine by the sequence of agents action. There are three types of synchronicity technique:

- a) *Sequential asynchronous execution*: Invoke each agent in sequential order. For example: agent 1, agent 2, agent 3, agent 4, then repeated again to agent 1, agent 2 and so on.
 - b) *Random asynchronous execution*: Invoke each agent in different random order at each time step.
 - c) *Simulated synchronous execution*: Invoke each agent in any convenient order but buffer all interactions with the agents' environment so that all inputs to agents are completed before all outputs.
- 2) *Event driven simulation*: In an event driven design only those agents that need to take action are invoked.
 - 3) *Calibrating time*: We need to consider the way to match the simulation time to the real world time.

In the fourth step, we need to consider how to verify and validate the model. Verification process aims to getting rid of bugs (Gilbert N. , Agent-Based Models, 2008). To avoid bug in the simulation program and to make finding them easier, there are several techniques that can be used (Ramanath & Gilbert, 2004) for example:

- 1) *Include lots of outputs and diagnostic*: we may not only display the final result of the simulation, but also should display the intermediate values of the calculation.
- 2) *Add assertions*: for variables that have specific range of values, we should code warning message if the value of the variable is out of range.
- 3) *Use unit testing*: we divide our simulation into several units. We supply a series of input to each unit then; compare unit's output with the expected output of the given unit. Usually, the expected output can be calculated manually.
- 4) *Test parameter values for known scenarios*: if there are scenarios for which the parameter and outputs are know with some degree of certainty, we can test whether the simulation can reproduces the expected behavior.
- 5) *Use corner testing*: We can test whether the simulation can produce reasonable outputs at extremes scenarios.

Validation for an agent-based simulation is a very difficult process (Gilbert N. , Agent-Based Models, 2008) and become the most debated topic until recently. For some researcher, model's validity depends on the ability of the models to predict or suitability of its output against empirical data from the real-world (Kuppers & Lenhard, 2005). However, mainly due to the non-linear interactions, a complex system will produce many outcomes for a single action (initial condition) (Agar, 2004; Wilson & Boyd, 2008) and conversely there are many causes (initial condition) for every single outcome (Richardson, 2002; Wilson & Boyd, 2008) as illustrated in Figure 2. Therefore, it is impossible to predict precisely all outcomes for a single action and, for one set of outcomes there is

also impossible to predict precisely which action will produce it (Wilson & Boyd, 2008). This implies that there is a possibility that the pattern observed in the real world is only a subset of all possible patterns generated by a complex system under a certain initial conditions.

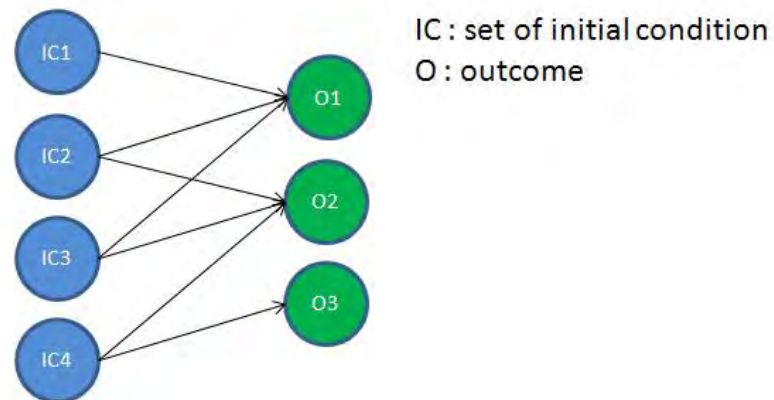


Figure 2 Relationship between initial condition and the resulted outcome in a complex system

By considering the relationship between initial conditions and outcomes that may occur then, there are at least three types of prediction that can be produce by a simulation model (Troitzsch, 2009):

- 1) Which kinds of behavior can be expected [from a system like this] under arbitrarily given parameter combinations and initial conditions? In this type of a prediction, the model is able to mimic some of observable outcomes generated by sets of initial conditions that are calibrated arbitrarily (randomly). Arbitrarily can mean that all elements of the initial condition are set randomly or, some elements of the Initial condition can be set so that they have the same quality with real-world conditions.
- 2) Which kind of behavior will a given target system (whose parameters and previous states may or may not have been precisely measured) display in the near future? In this type of a prediction, the model is able to mimic some of observable outcomes when at least some elements of the initial condition can be set so that they have the same quantity with real-world conditions.
- 3) Which state will the target system reach in the near future, again given parameters and previous states which may or may not have been precisely measured? The prediction of type 3 can even be subdivided in a stochastic or statistical version and a deterministic one:
 - a) Which are the expected value and the confidence interval around the expected value of the state the target system will reach in the near future, again given parameters and previous states which may or may not have been precisely measured?
 - b) Which exact value will the state of the target system have at a certain point of time in the near future, again given parameters and previous states which have been precisely measured?

Furthermore, the agent based model (prediction) validity can be classified into several levels (Axtell & Epstein, Agent Based Modeling: Understanding Our Creations, 1994):

1. *Level 0*: the model is caricature of reality that able to visualize agent's movement.
2. *Level 1*: The model is in qualitative agreement with empirical macro structure. For example the segregation model by Schelling (Schelling, 1971). The simulation result can show that, there is always a pattern of clusters of adjacent households of the same color. Although this model cannot show any numerical measure, the similar pattern can be observed in the real world.

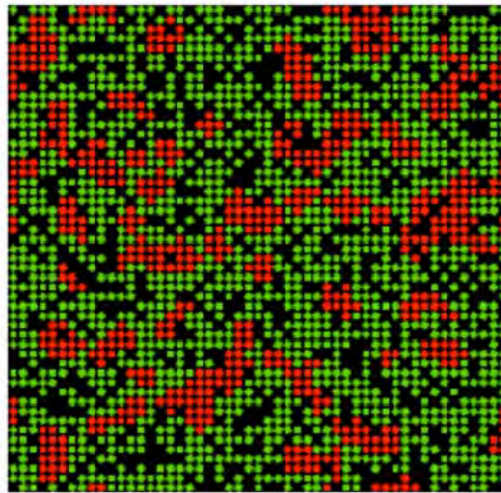


Figure 3 The simulation result of segregation model by Schelling

3. *Level 2*: The model is in quantitative agreement with empirical macro structure. In this level, the pattern in the real world can be estimated by the model. For example, in the simulation of environmental innovations diffusion, Schwarz can show that in the year of 2004 the majority of household in Germany used stop button tank, followed by standard, direct flush and dual flush tank (Schwarz, 2007). This pattern is similar with the pattern in the real world for the given year and we can also measure the difference between the simulation result and the real system.

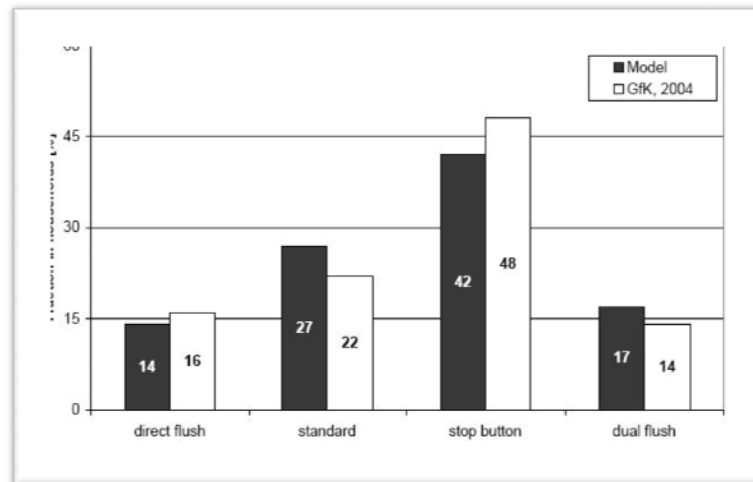


Figure 4 the simulation result of the diffusion of environmental innovations model

4. *Level 3*: The model is in quantitative agreement with empirical micro structure. In this level of accuracy, the evolution in the model is similar with the evolution in the real world. An example of model with this level of accuracy is the artificial Anasazi model (Axtell, et al., 2002). This model simulates the population dynamics between 800 until 1350 BC in the Long House Valley in Arizona.

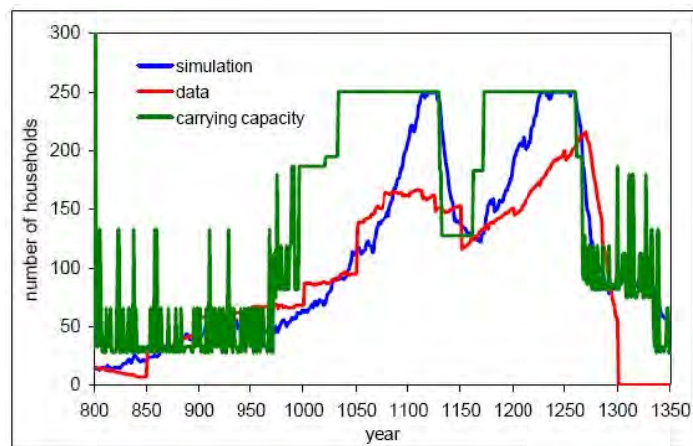


Figure 5 Simulation result of artificial Anasazi model

Emotion in Negotiation Simulation

Emotion is complex, and this term has no single universally accepted definition. For example, emotions can be described as conscious states (LeDoux, 1994), cognitive processes (Sloman, 1981), psychosocially constructed, dramatized feeling (Masters, 2000), or mental states that arise spontaneously, rather than

through conscious effort. Other descriptions involve adaptive dispositions, evaluative judgments, or even social facts or dynamical processes (de Sousa, 2003). Emotions are physical expressions, often involuntary, related to feelings, perceptions or beliefs regarding elements, objects or relations between them, in reality or in the imagination. Thus, the study of emotions is part of psychology, neuroscience, and, more recently, artificial intelligence.

Current research on the neural circuitry of emotion suggests that emotion makes up an essential part of human decision-making, including long-term planning. Emotions are passions for reasoning, which makes the brain system to be enmeshed in need of reasoning (Damasio, 1994). However, emotion was sometimes regarded as the antithesis of reason. But, some state that there is no empirical support for any generalization suggesting the antithesis between reason and emotion: indeed, anger or fear can often be thought of as a systematic response to observed facts. In any case, it is clear that the relation between logic and argument on one hand and emotion on the other is one which merits careful study.

For human beings, negotiations often evoke many kinds of emotions. Emotions can cause intense and sometime irrational behavior, and can cause conflicts to escalate and negotiations to break down (Adler, Rosen, & Silverstein, 1998). Previous research shows that emotions play positive and negative roles in negotiation. Both hiding emotions and making vigorous displays of emotion can be effective negotiating tactics. On the positive side, emotions make us care for our own interests and about people. Empathy can improve understanding and facilitate communication. Legitimately expressed anger may communicate the party's sincerity and commitment. Conversely, fear and anger usually play negative roles in negotiation. Li and Roloff (Li & Roloff, 2006) suggests that while positive emotion leads to cooperation and greater joint gain, negative emotion leads to competition and greater individual gain because of the different cognitive processing styles associated with each emotion. Thus, emotion does influence negotiators' cognitive processing, and then affect negotiation outcomes for human beings.

To integrate emotion into negotiation simulation a model that can describe the emotions numerically is required. The PAD (Pleasure-Arousal-Dominance) emotional state model is a general but a precise three-dimensional approach to measuring emotions. Mehrabian (Mehrabian A. , 1996) developed three nearly orthogonal dimensions, namely:

- 1) Pleasure–Displeasure (P): This dimension gives the direction of emotions, positive emotion status / negative emotion status. Generally, a positive emotional state is more conducive for a person to act in a friendly and sociable manner with others; conversely, a negative emotional state tends to heighten chances that the individual will be unfriendly, inconsiderate, or even rude to others. During negotiation, a more

pleasant agent tends to cooperate with others or tends to accept others' offers; in contrast, a more unpleasant agent tends to reject others' offers. We can reflect this relationship to the value system by assuming that pleasure makes the agent increase the evaluation value and displeasure makes the agent decrease the value (Jiang, 2007).

- 2) Arousal–Non-arousal (A). This dimension represents the degree of effects on the pleasure dimension. Arousal means to rouse or stimulate to action or to physiological readiness for activity. This dimension magnifies or minimizes P's affection. For example, if an agent is in pleasure status this emotion makes the agent increase the evaluation value a little; if the agent is also on arousal, it increases even more. But, if the agent is in displeasure, then arousal will make the agent decrease the value more (Jiang, 2007).
- 3) Dominance–Submissiveness (D): This dimension reflects the degree of the ability of being commanding, controlling, or prevailing over all others, or degree to yield oneself to the authority or will of another. The agent in a dominant state or with more power tends to persist in its own proposal and benefit more in negotiation. This dimension can be related to the value system of negotiation by assuming that since a dominant agent tends to persist in its own proposal it will tend to decrease the evaluation value. On the other hand, if the agent is submissive, it will tend to yield and accept the other agent's proposal (Jiang, 2007).

Specific emotions can be represented by points in a three-dimensional PAD emotion space. If the PAD scale scores are standardized then, each emotion can be described concisely in terms of its values on the pleasure - displeasure, arousal – non-arousal, and dominance-submissiveness axes. For example, when emotions are scored on each PAD scale range from -1 to +1: angry (-.51, .59, .25), bored (-.65, -.62, -.33), curious (.22, .62, -.01), dignified (.55, .22, .61), elated (.50, .42, .23), hungry (-.44, .14, -.21), inhibited (-.54, -.04, -.41), loved (.87, .54, -.18), puzzled (-.41, .48, -.33), sleepy (.20, -.70, -.44), unconcerned (-.13, -.41, .08), violent (-.50, .62, .38).

In the PAD Model, there are eight basic and common varieties of emotion, as defined by all possible combinations of high versus low pleasure (+P and –P), high versus low arousal (+A and –A) and high versus low dominance (+D and –D) (Mehrabian A. , 1996; Mehrabian A. , Relationships among Three General Approaches to Personality Description, 1995; Mehrabian A. , Framework for a Comprehensive Description and Measurement of Emotional States, 1995). These combinations are specified in Table 1.

Table 1 Basic Variety of Emotion and Sample of Emotions in PAD Scale

PAD Labels	Varieties of Emotion	Sample Emotion Terms
(+P+A+D)	Exuberant	Admired, bold, carefree, dignified, elated, excited, masterful, mighty, triumphant
(+P+A-D)	Dependent	Amazed, curious, fascinated, grateful, impressed, loved, respectful
(+P-A+D)	Relaxed	At ease, comfortable, relaxed, satisfied, secure, unperturbed
(+P-A-D)	Docile	Consoled, cruel-admired, docile, domineering-timid, humiliated-lonely, protected, reverent, sleepy, tranquilized
(-P+A+D)	Hostile	Angry, catty, cruel, defiant, hostile, insolent, nasty, unmotivated-distressed, violent
(-P+A-D)	Anxious	Aghast, bewildered, distressed, fear, frustrated, hungry, in pain, insecure, neuroticism, puzzled, anxiety, upset
(-P-A+D)	Disdainful	Amazed-daring, awed-domineering, disdainful, humiliated-sad, indifferent, selfish-uninterested, uncaring, unconcerned
(-P-A-D)	Bored	Bored, despairing, fatigued, inhibited, lonely, sad, sluggish, subdued

Taking into account the ability of the PAD model to describe the emotions in general and in numerical form, then the model is considered suitable as a base of a model of the dynamics of conflict that involves emotion and learning.

METHODOLOGY

This study begins with literature review of the previous studies, which aims to identify the latest developments of the Citarum river basin conflict, concepts relating to drama theory, agent-based simulation and the PAD emotional model. Based on the results of this literature review new important information about the Citarum river basin conflict can be added and the limitations in the previous simulation mechanism can be improved.

The second step of this research is to conduct field observations and focus group discussion with stake holders in Citarum river basin conflict. Stakeholders involved in this process come from government, NGOs, community members, public enterprises, and business. This step aims to obtain a description of the current condition of Citarum river basin conflict. Based on the obtained data, common reference frames of Citarum river basin conflict were constructed. These common reference frames describe the historical dynamics of Citarum river basin conflict. To test model's robustness to the dynamics of common reference frame and the emergence of new options, the the conflict's chronological history is divided into two different milestones (resulting two scenarios). Each scenario consists of two common reference frame that is the common reference frame before the milestone and the common reference frame after the milestone. By using two common reference frames for each scenario, agent's efforts to reduce the dilemmas at that time period can be identified. In addition, the emotional dynamics of each agent toward the other agents can also be estimated.

In the third stage of the research the proposed mechanism is constructed. The construction of the proposed model begins by defining agents and its attributes (Gilbert N. , 2004) such as agent's positions, emotions and payoffs. After that, the interaction mechanisms among agents are deductively constructed (Gilbert & Terna, How to Build and Use Agent-based Models in Social Science, 2000). The interaction mechanisms consist of several modules such as, negotiation protocol module, emotional dynamic module, learning module etc.

The next fourth stage is to conduct verification of the simulation. Verification process is intended to test the internal consistency of the simulation mechanism (Gilbert N. , 2004). In this process test are conducted to evaluate whether the behavior shown by the simulation is purely caused by the constructed mechanism and not caused by programming errors/bugs. To avoid bugs in the proposed model, unit testing and corner testing technique are used. In unit testing technique, the proposed model is divided into several units. A series of input for each unit is then supplied; the unit's outputs are then compared to the expected output of the given unit (Ramanath & Gilbert, 2004). Usually, the expected output can be calculated manually. In corner testing technique, the proposed model is tested whether it can produce reasonable outputs at extremes scenarios or not (Ramanath & Gilbert, 2004).

After the simulation is verified, the next stage is to conduct virtual experiments. The virtual experiments in this study consist of three parts. The first part of the experiment aims to analyze model's sensitivity. The sensitivity analysis is important to determine whether the dynamics shown by the proposed model are caused by the variation of supplied inputs or just an effect of random nature of the model. The sensitivity analysis is also important to determine the robustness of model analysis. The second part of the experiment aims to test the validity of the proposed model's predictions. In this process the model is tested whether its outputs can show qualitative or quantitative agreement with empirical macro structure in the real world (Gilbert N. , 2004) or not. If the proposed model predictions are valid, then it is feasible to produce suggestion for the decision maker in the real world conflict. The third part of the experiment aim to explore patterns that can be generated by the proposed model. Based on these patterns, possible suggestions in order to achieve resolution in Citarum river basin conflict are inferred. These suggestions can take form of policy recommendations or identification of types of agent's behavior that support collaboration.

The general description of the research methodology is shown in Figure 6.

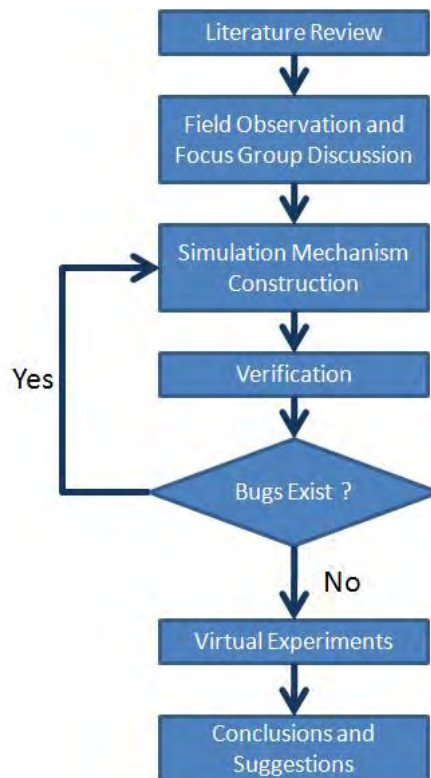


Figure 6 research Process Flow Chart

CASE STUDY

Case Background

Citarum River basin is a region in Java Island, Indonesia, with 6,080 km² area crossing three provinces, *i.e.*, West Java, Banten, and Jakarta. Citarum upstream located in Wayang Mountain, in south Bandung and the downstream is located in Karawang, with total length of 225 km (citarum.org). Citarum River flows through ten regencies and the cities *i.e.* Bandung Regency, Bandung City, Purwakarta Regency, Cianjur, Garut, Sukabumi, Sumedang, Karawang, Bogor and Bekasi (Balai PSDA Wilayah Sungai Citarum, 2004). Citarum River is connected with 4 rivers to the west and 4 rivers to the east in West Java. The annual precipitation depth is 3,000 mm/year in the mountain and 2,500 mm/year in lowland. Relative humidity is 80% and daily temperature is 25°C in the lowland and 18°C in the mountain. Figure 7 shows the vast area covered by the Citarum river basin. Point A in Figure 7 shows the upstream area of Citarum River while point B shows the downstream area of the Citarum River.



Figure 7 Citarum River Basin Area

Citarum River is one of the strategic rivers in Indonesia. Almost everyone along Citarum River utilize its water to support their life. Citarum river water used for drinking water, industry, agriculture, power generation, flood control and river keepers. Citarum River generates 1,350 MW of electric power, irrigates 240,000 ha of rice fields, provides 45.75 billion cubic of water for industry, 43.3 billion m³ of water for fisheries, and 400.5 billion m³ of water for domestic purposes

(Puslitbang Sumber Daya Air, 2005). In addition, Citarum River also became the recreation object for the community.

In the past Citarum River can perform these functions well, but those conditions have now changed completely (Sungkono, 2005). Floods always occur during the rainy season because of sedimentation at Citarum river downstream region, and the increasing number of barren land (Umar, 2005). Citarum River even takes seventh position of the ten dirtiest rivers in the world, in 2010 (Tribun, 2010).

There are several causes of the Citarum River Basin problem. The first is the population explosion that occurred at the upper stream region (Maulana, 2003) that led to an increase in illegal lodging and deforestation in the upper stream region. Second is household waste into the river. Along the Citarum River there are \pm 8 million residents who could potentially produce household waste (Pemerintah Propinsi Jawa Barat, 2002). Nowadays, at least 200 tons of household wastes are thrown away into Citarum. In addition, many of industries do not perform waste treatment before throwing them away into Citarum River (Sungkono, 2005). In the Citarum river basin there are 1000 industries that use surface water, as well as producing industrial waste (Pemerintah Propinsi Jawa Barat, 2002). The flood and the dirty river water in have caused many kinds of diseases suffered by the community along the Citarum River.

The problem in Citarum River basin involves many agents. In fact there are hundreds of agents involved in the conflict in the Citarum River Basin. These agents consist of central government agencies, provincial government agencies, city agencies / counties and villages, state-owned enterprises, NGOs at the regional level and NGOs at local level. Through literature studies conducted on mass media, reports and previous studies hundreds of agents that play significant role in Citarum River Basin Conflict from 2007 until now are identified. These agents can be classified as follows:

1. **Business Sector:** This group consists of investors and private business such as, real estate entrepreneurs, factory outlets of textile industries. The group is interested in using the Citarum River Basin area as their business establishment *e.g.* factories, factory outlets, hotels, etc. Their business establishments sometimes violate the established provisions for example; covering the city drainage to build parking lots. They are also significant users of surface water in Citarum River and frequently also dispose their waste in to the Citarum River.
2. **Community:** Groups of community such as farmer alliance, woodlander alliance, merchant alliance, etc. This group needs the land in Citarum River Basin for housing and agriculture. This group utilizes Citarum river water for irrigation, domestic usage and sometimes they also produce household waste that is dumped into the river Citarum. Because they lived close to the Citarum River this group also become the main victims of flood and contamination that occurred in the Citarum River. The members of this group

among other are, farmers in the upperstream of Citarum river, residents in Bale Endah, residents in Andir district, farmers in the northern coast of Java island etc.

3. **Government:** Group of agents who have authorities to make official policies, e.g. central government agencies, provincial government agencies, city agencies / counties agencies. The interest of this group members are to prevent floods in the area, to preserve nature in the Citarum River Basin, to maintain the availability of water supplies, to improve the welfare of the people in the Citarum river basin and to earn regional revenue. The members of this group among other are, the government of Bandung city, the government of Bandung regency, the government of West Bandung Regency, the Ministry of Public Works, BAPEDA (Regional Development Agency), BBWS (Central River Region Agency) Citarum, Perhutani (Indonesian Forestry Agency), PSDA (Natural Resources Development Agency), etc.
4. **NGO:** Group of nonprofit institutions that consists of professionals, community leaders, environmentalist, academicians and humanist. Members of this group are eager to prevent floods in the area, to preserve the nature in the Citarum River Basin, and to improve community welfare and health. The members of this group among other are, DPLKTS (Board of Forestry and Environmental Observer in Tatar Sunda), Bandung Green and Clean, Bina Mitra, Walhi, Arum, Kruha, etc.
5. **Public Enterprise:** A group of agent that consists of State owned enterprises and regional owned enterprises that are responsible to serve the public and to gain profit for the company. The members of this group among other are, PDAM (Regional Drinking Water Company), PJT (Perum Jasa Tirta (National Drinking Water Company)), and Indonesian Power (Electricity Company). Citarum river water is a resource for the agents in this group. PDAM and PJT require Citarum river water to be converted into drinking water while Indonesia Power requires Citarum river flow to generate electricity. The decline in water quality and sedimentation of the river Citarum diminish the quality of the resources obtained by the public enterprises and automatically reduce their ability to serve the community and making profit.

There are many programs and proposals that have been produced through the interaction and negotiation among these agents. As one example is *Citarum Bergetar* program that was initiated in 2001. This program consists of general policy and law to control, to restore and to conserve Citarum River and also involving community empowerment programs (BPLDH Jawa Barat, 2001). However, because each agent has different interests, these programs and proposals cannot produce a significant impact on the improvement of Citarum River Basin conditions. Another example is Integrated Water Resources Management (IWRM) program in 2008 (Santono & Goeltom, 2011). This program aims to manage sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives systematically.

Each agent has different role and different activity at each time period and at each program. In addition, agent's alignment, cooperation, coalition, options and positions may also vary at each time period. In order to be able to test proposed model's robustness to these dynamics, the Citarum River Basin conflict is portrayed at two different milestones (resulting two scenarios). The first milestone is in 2008 and the second milestone is in 2009. Time line of common reference frames which are portrayed in this study is illustrated in Figure 8. In Figure 8, the period between 2008 and 2009 was a transition period in which there are several changes in agent's options.

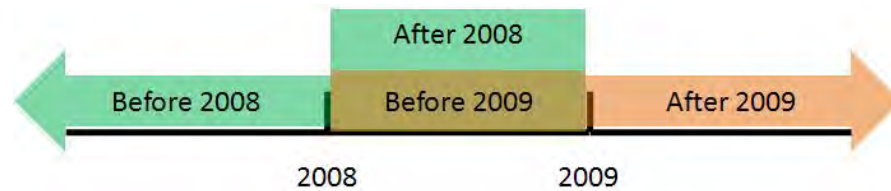


Figure 8 Time line of Citarum River Basin Common Reference Frames

Scenario 1: Citarum River Basin Conflict Before and After 2008

Through focus group discussions and literature study, options that are owned by each agent during this period can be identified. Those options are described as follows:

- 1) Business Sector options:
 - a. **Stop damaging drainage:** In developing the business location, business sector gives attention and maintain the city's drainage. Not to cover the drainage channels in order to convert it into a parking lot. Prevent their customers from disposing garbage into drainage channels.
 - b. **Stop polluting Citarum:** Not to dispose of industrial waste into Citarum River and constructing Waste Water Treatment Plants (WWTP).
- 2) Community options:
 - a. **Protest:** An action by community, especially flood victims. It is normally consists of walking in a mass march formation, destroying building, public facilities, etc.
 - b. **Stop illegal logging:** Stop damaging the forest to conduct seasonal agriculture, to build illegal housing, and to steal timber.
 - c. **Stop waste disposal to river:** Not to dispose of house hold waste into Citarum River.
- 3) Government
 - a. **Maintain downstream river:** Facilitate the maintenance of downstream areas such as rivers, preparing waste disposal sites, build a septic tank, pushing the recycling movement, etc.

- b. **Give sanction to people:** give strict and clear sanction to community member who steal timber, conduct seasonal agriculture, dispose household waste into the river, or build illegal housing.
 - c. **Give sanction to business sector:** give strict and clear sanction to business sector that destroy city's drainage, doesn't have WWTP, or dispose industrial waste into the river.
 - d. **Give real estate license:** give permission to construct real estate and villas in Citarum's upper stream area.
 - e. **Giving More Authorities for green and Public Enterprises:** There are limited authorities for Green and Public Enterprises to do their job. Green needs authority to handle curative programs of Citarum, and public enterprises need authority to develop some programs independently to gain more income without government intervention. The programs need to be carried out by public enterprises including the Citarum river conservation program by empowering the community. These programs are necessary because of the Citarum River is one of resources for public enterprises.
- 4) NGO
- a. **Protest:** confrontationally against government policies that do not support the preservation of nature.
- 5) Public Enterprise
- a. **Proactively protect the environment:** Participate actively in efforts to maintain the Citarum River Basin, both in the upstream and downstream area.

Based on observation, focus group discussion and literature study, the positions taken by each agent before 2008 are described by the common reference in Table 2.

Table 2 Common Reference Frame of Citarum River Basin Conflict Before 2008

Agent's Option	Threat	Agent's Position				
		BS	C	G	NGO	PE
Business Sector		>>	>>	>>	>>	>>
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes
Community		<<	>>	>>	>>	>>
Protest	Yes	No	Yes	No	Yes/No	Yes/No
Stop illegal logging	No	No	No	No	Yes	Yes
Stop waste disposal to river	No	Yes/No	No	Yes	Yes	Yes
Government		<<	>>	>>	>>	>>
Maintenance down stream river	No	No	Yes	No	Yes	Yes
Give sanction to people	No	No	No	No	Yes	Yes
Give sanction to business sector	No	No	Yes	No	Yes	Yes
Give real estate lisenca	Yes	No	No	Yes	No	No
Giving more authorities for public enterprises	No	Yes/No	Yes/No	No	Yes	Yes
NGO		<<	<<	<<	<<	<<
Protest	Yes	No	Yes	No	No	No
Public Enterprise		<<	>>	>>	>>	>>
Pro active for agency sustainability	No	Yes/No	Yes/No	Yes/No	Yes	Yes

After 2008, there are significant changes in agent's attitudes. Prior to 2008 the government was reluctant to cooperate with NGOs and Public Enterprise in efforts to preserve the Citarum River Basin. However, after 2008, especially after the implementation of IWRM, the government became more open and inviting Community, NGOs and the Public Enterprise to participate in efforts to preserve the Citarum River Basin. This was revealed through focus group discussions with government's representative.

"...We already do our best to socialized government's programs to prevent Citarum become worse, after that we need to make peoples realize the importance of our programs, with periodical control from government and NGOs" – Mrs.Widya (FGD Representative from West Bandung Regency)

Since to give more authorities are desired by the NGOs and public enterprise, government's willingness to cooperate with them can be related to docile or compliant emotion. This indicates that in general government's pleasure was increasing and government's arousal and dominance were decreasing (+P-A-D).

Along with the government's willingness to give more authority to public enterprise, public enterprise efforts to become more proactive in environmental conservation efforts Citarum River are increasing. This was revealed in focus group discussions with representatives of PDAM and Indonesian Power.

"..., we can't work without Citarum, because that river becomes the only river to move Saguling dam. That's why we are really concern to keep the river clean from waste, sedimentation and

seasonal agriculture. We still don't have enough budget and capability, but now we can always try to make Citarum condition better. As an example, now we have a reforestation program in Manglayang" – Mr.Alimin (FGD Representative from Indonesia Power)

"...now we can do the conservation project, we have the budget for that, we have the CSR also, give the support to peoples, NGO and research...." – Mr.Yusuf (FGD Representative from PDAM)

Attitude shown by the public enterprise in this interval reflects that they are eager to do conservation in Citarum River Basin. Their eagerness can be related to excited or elated emotions. This indicates that in general public enterprise's pleasure, arousal and dominance were increasing **(+P+A+D)**.

Community, in the period before 2008, often carried out protest that was intended primarily to the industries that dump industrial waste into Citarum River. However, they did not get serious responses they eventually top these efforts. This was revealed through focus group discussions with community's representative.

"...we used to do some protest, but the industries were not care with us, so we are angry and damage the factory's pipes" – Mr.Arif (FGD Representative from Community)

Attitude shown by the community at this time interval reflects that they have become frustrated against industries that are in the Citarum River Basin. This attitude can be related to distressed or frustrated emotion. This indicates that in this period community's pleasure and dominance were decreasing while their arousal was increasing **(-P+A-D)**.

Taking into account the actions taken by each agent, then changes occur in the common reference frame after 2008. The positions taken by each agent after 2008 are described by the common reference in Table 3.

Table 3 Common Reference Frame of Citarum River Basin Conflict After 2008

Agent's Option	Threat	Agent's Position				
		BS	C	G	NGO	PE
Business Sector		>>	>>	>>	>>	>>
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes
Community		<<		>>	>>	>>
Protest	Yes	No	No	No	Yes/No	No
Stop illegal logging	No	No	No	No	Yes	Yes
Stop waste disposal to river	No	Yes/No	No	Yes	Yes	Yes
Government		<<	>>		>>	>>
Maintenance down stream river	No	No	Yes	No	Yes	Yes
Give sanction to people	No	Yes	No	No	Yes	Yes
Give sanction to business sector	No	No	Yes	No	Yes	Yes
Give real estate lisencc	Yes	Yes	No	Yes	No	No
Giving more authorities for public enterprises	No	Yes/No	Yes/No	Yes	Yes	Yes
NGO		<<	<<	<<		<<
Protest	Yes	No	Yes	No	No	No
Public Enterprise		<<	>>	>>	>>	
Pro active for agency sustainability	No	Yes/No	Yes/No	Yes	Yes	Yes

Table 3 shows that there are changes in agent's positions after 2008. After 2008 the government is adopting their giving more authorities option while, the community abandon their protest option.

Scenario 2: Citarum River Basin Conflict Before and After 2009

It has been discussed in Scenario 1 that after the year 2008, exactly after the implementation of IWRM, the government has given more authority to the Public Enterprise to carry out preservation programs in Citarum River Basin. Thus this option is no longer relevant for the government after 2008. This is because the decision to contribute to the preservation of the Citarum River now lies in the hands of Public Enterprises. Therefore, two new options are defined for public enterprise *i.e.* to do to conduct reforestation and to regulate waste disposal. The emergence of these two options is due the fact that to conduct reforestation and to regulate waste disposal will require different strategies and policies by the public enterprise.

Through focus group discussions and literature study, options that are owned by each agent before 2009 can be defined. Those options are described is as follows:

1) Business Sector options:

- a. **Stop damaging drainage:** In developing the business location, business sector gives attention and maintain the city's drainage. Not to cover the drainage channels in order to convert it into a

- parking lot. Prevent their customers from disposing garbage into drainage channels.
- b. **Stop polluting Citarum:** Not to dispose of industrial waste into Citarum River and construct Waste Water Treatment Plants (WWTP).
- 2) Community options:
- a. **Protest:** An action by community, especially flood victims. It is normally consists of walking in a mass march formation, destroying building, public facilities, etc.
 - b. **Stop illegal logging:** Stop damaging the forest to conduct seasonal agriculture, to build illegal housing, and to steal timber.
 - c. **Stop waste disposal to river:** Not to dispose of house hold waste into Citarum River.
- 3) Government
- a. **Maintain downstream river:** Facilitate the maintenance of downstream areas such as rivers, preparing waste disposal sites, build a septic tank, pushing the recycling movement, etc.
 - b. **Give sanction to people:** give strict and clear sanction to community member who steal timber, dispose household waste into the river, or build illegal housing.
 - c. **Give sanction to business sector:** give strict and clear sanction to business sector that destroy city's drainage, dispose industrial waste into the river.
 - d. **Give real estate license:** give permission to construct real estate and villas in Citarum's upper stream area.
- 4) NGO
- a. **Protest:** confrontationally against government policies that do not support the preservation of nature.
- 5) Public Enterprise
- a. **Regulate the waste disposal:** Helps to reduce the amount of waste that goes into the river by building a waste filter in upstream areas, educate the community, invite the community to clean up the river.
 - b. **Reforestation:** Carry out reforestation in the upstream areas and encourage people conduct reforestation by holding lectures and develop perennials plantation business.

Based on observation, literature study and focus group discussion, positions taken by each agent before 2009 can be described by the common reference in Table 4.

Table 4 Common Reference Frame of Citarum River Basin Conflict Before 2009

Agent's Option	Threat	Positions				
		BS	C	G	NGO	PE
Business Sector			>>	>>	>>	>>
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes
Community		<<	>>	>>	>>	>>
Protest	Yes	No	No	No	Yes/No	No
Stop illegal logging	No	No	No	No	Yes	Yes
Stop waste disposal to river	No	Yes/No	No	Yes	Yes	Yes
Government		<<	>>	>>	>>	>>
Maintenance down stream river	No	No	Yes	No	Yes	Yes
Give sanction to people	No	Yes	No	No	Yes	Yes
Give sanction to business sector	No	No	Yes	No	Yes	Yes
Give real estate lisenze	Yes	Yes	No	Yes	No	No
NGO		<<	<<	<<	<<	<<
Protest	Yes	No	Yes	No	No	Yes
Public Enterprise		<<	>>	>>	>>	>>
Regulate the waste disposal	No	No	No	Yes	Yes	Yes
Reforestation	No	No	Yes/No	Yes	Yes	Yes

After 2009, there are significant changes in agent's attitudes. Communities in this period are become more aware and do protest, because the Citarum River's conditions is getting worst. Floods occur more often in rainy season and water's quality decreasing further. However, unlike the previous protest, protest at this period is more intended to the government. This was revealed in focus group discussions with community representatives.

"....., community was protests to the factory but the factory responded negatively so that community gives up protesting to the factory. The community then chose to protest to government. Community asked the government to make WWTP to address flooding around Citarum river. However, the government proposed to use artesian as another alternative solution, but people did not agree with that solution because of water quality."
 – Mr. Deni Riswandani (FGD representative from Elingan NGO).

These attitudes show that the community is increasingly anxious and frustrated with the current condition of the Citarum River. In the PAD model, this shows a decrease in pleasure and dominance, and an increase in arousal (**-P+A-D**).

In order to improve Citarum river condition, government in this period makes some action to reduce the sedimentation by cooperating with public enterprises and NGOs. This was revealed through discussions with officials of Regional Development Agency of Bandung City.

"...Bandung City implemented a program called "Cikapundung Bersih" which concerning sedimentation problem. Sedimentation was exists in several certain places such as PLN and in Soekarno

Hatta. This process is not only done by the city government because it involves several other stakeholders such as BRI, PLN, and NGOs...". – Mr. Anwar (FGD representative from Bandung Local Government Agency).

In addition, the government was also review a lot of real estate license and give sanction to business establishments which design violates government provisions. Government's willingness to cooperate with other agents indicates that in general government's pleasure, arousal and in dominance are increasing (+P+A+D).

NGOs in this period also make some positive activity such as cleaning, educating and empowering the community to protect the river. This was revealed through discussions with the representatives of Bandung Green and Clean (BGC).

"First, we urge people to improve their participation. This is commonly referred to as the implementation of community empowerment. This is also related to environmental activities that we can know how its progress. Secondly, we are taught how to manage waste in the home. Third, we do greening at home. It is not just an ornamental plant, but also growing vegetables and medicinal plants at home. Fourth, save water when the rainy season and keep the water when the dry season. Waste is not disposed carelessly, and makes better treatment at home." –Mr. Rohadji (FGD representative from Green and Clean NGO).

NGO's willingness to empower the people and cooperate with other agents such as business, government and public enterprises indicates increase in pleasure, arousal and in dominance (+P+A+D).

Public Enterprises also made significant efforts to make Citarum become cleaner. Their efforts also involve community member and NGOs. This was revealed through discussions with the representatives of Indonesian Power and PDAM (Regional Water Company).

"..... we are really concern to keep the river clean from waste, sedimentation and seasonal agriculture. As an example, we have a reforestation program in Manglayang [Mountain]" – Mr. Amin Alimin (FGD Representative from Environmental Unit officials of Indonesia Power).

"...beside we taking the water, we also conserve and cooperate with PERHUTANI, to conserve the environment, For spring problem, usually we cooperate with PERHUTANI, so we have a special budget for that" – Mr. Ahmad Yusuf (FGD representative from PDAM 2nd production unit)

Public Enterprise's willingness to cooperate with other agents indicates increase in pleasure, arousal and in dominance (**+P+A+D**).

From the quotations above, it can also be concluded that, the business sector was uncared especially to the community and NGOs complaints. This attitude indicates that the business sector pleasure and arousal is decreasing while its dominance increasing (**-P-A+D**).

Actions done by agents during this period lead to changes in the common reference frame after 2009. The positions taken by each agent after 2009 are described by the common reference in Table 5.

Table 5 Common Reference Frame of Citarum River Basin Conflict After 2009

Agent's Option	Threat	Positions				
		BS	C	G	NGO	PE
Business Sector			>>	>>	>>	>>
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes
Community		<<		>>	>>	>>
Protest	Yes	No	Yes	No	Yes	No
Stop illegal logging	No	No	No	Yes	Yes	Yes
Stop waste disposal to river	No	Yes	No	Yes	Yes	Yes
Government		<<	>>		>>	>>
Maintenance down stream river	No	No	Yes	Yes	Yes	Yes
Give sanction to people	No	Yes	No	No	Yes	Yes
Give sanction to business sector	No	Yes	Yes	Yes	Yes	Yes
Give real estate lisenca	Yes	No	No	Yes	No	No
NGO		<<	<<	<<		<<
Protest	Yes	No	Yes	No	Yes	Yes
Public Enterprise		<<	>>	>>	>>	
Regulate the waste disposal	No	No	No	Yes	Yes	Yes
Reforestation	No	No	Yes/No	Yes	Yes	Yes

Table 5 shows that there are changes in agent's positions after 2009. After 2009 the community is adopting their protest options and also hopes that NGOs are supporting them. The community also becomes more participative in public enterprises reforestation efforts. Government become more aware to maintain the downstream river to give sanction to business that violates regulations. NGOs are also become more active in criticize government and business sector in case of violations.

MODEL CONSTRUCTION

This section describes steps in constructing the proposed model. The agent-based simulation model in this study was constructed using NetLogo version 4.1.2. For each modeling step, the implementation processes in NetLogo and verification processes are also explained.

Model of Agents, Options and Positions

In the drama theory framework of a conflict will involve a number of agents who have a number of options. Interaction among agents is represented in a table called the common reference frame. Each column in this table represents an agent while, the rows represent options owned by each agent.

Let O_{ki} are options owned by agent i , where k is the number of options of agent i . In every iteration t , agent i can choose to *accept* or *reject* each option O_{ki} . Positions of agent i at iteration t toward its own option are defined as c_{ki}^t , where:

$$c_{ki}^t: o_{ki} \begin{cases} 1 \rightarrow \text{if agent } i \text{ accept option } O_{ki} \\ -1 \rightarrow \text{if agent } i \text{ reject option } O_{ki} \end{cases} \quad (1)$$

Each agent j can choose to *accept*, *reject* or *indifferent* toward options O_{ki} of agent i . Position of agent j toward option k of agent i at iteration t is defined as c_{kij}^t , where:

$$c_{kij}^t: o_{kij} \begin{cases} 1 \rightarrow \text{if agent } j \text{ accept option } O_{ki} \\ 0 \rightarrow \text{if agent } j \text{ indifferent option } O_{ki} \\ -1 \rightarrow \text{if agent } j \text{ reject option } O_{ki} \end{cases} \quad (2)$$

Thus the common reference frame at iteration t can be represented as a matrix of each agent's position toward all available options as follows:

$$p^t = \{p_1^t, p_2^t, \dots, p_n^t\}; n = \text{number of agent} \quad (3.a)$$

With;

$$p_i^t = \{c_{ki}^t(o_{ki})\} \cup \{c_{kij}^t(o_{kij})\} \quad (3.b)$$

In the proposed model, positions of each agent serve as inputs in the form of matrix that is called as *position matrix*.

Exhibit 1

Suppose there are two agents who each have one option, with the position described in Table 6.

Table 6 Illustration of common reference frame model

	Agent 1	Agent 2
O ₁₁	C ₁₁ : accept	C ₁₁₂ : reject
O ₁₂	C ₁₂₁ : reject	C ₁₂ : accept

Then the *position matrix* that is used as input in the model is as follows:

$$\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \quad (4)$$

In the program implementation, each element in the matrix position is represented by one patch in NetLogo's pond. In order to ease model visualization, each agent's position is indicates by using colors, green for accept, red for reject and blue for indifferent. The implementation result of the given position matrix in NetLogo is illustrated in Figure 9.

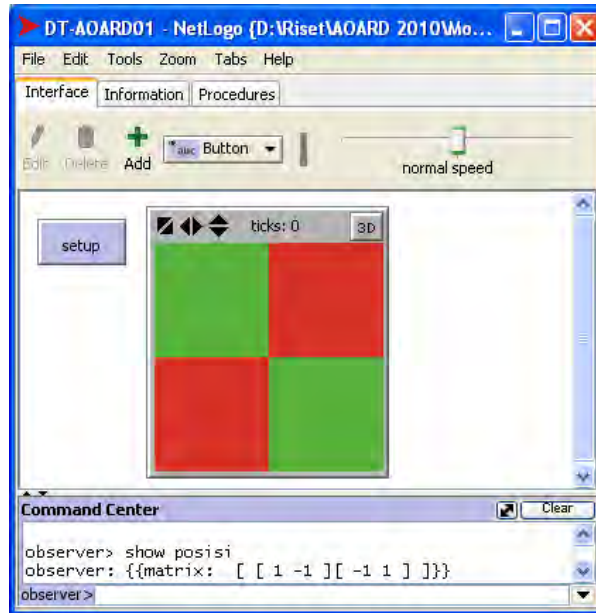


Figure 9 Illustration of implementation result of position matrix

Model of Agent's Payoffs

In the proposed model agents are assumed would negotiate each other by using its payoffs. Any position taken by agent is assumed will generate a certain payoff for the respective agent. In this study, it is assumed that the payoff is consists of two dimensions *i.e.* accept dimensions and reject dimensions. The total score of

the two dimensions are assumed to be equal to 100. If an agent chose to accept an option then, it is assumed that agent's payoff to accept the dimension is Greater Than its payoff to reject dimension. If an agent chose choose to reject an option then, it is assumed that the payoff to the agents reject dimension greater than the payoff agent to accept the dimension. If an agent is indifferent toward an option then, the payoffs that Will be obtained in both accept and reject dimension dimension are assumed to be equal to 50.

By using above assumptions Voa_{ki}^t is defined as payoff that will be obtained by agent i at iteration t if its option k^{th} is adopted. The value of Voa_{ki}^t in the proposed mechanism is then assigned as follows:

$$Voa_{ki}^t: c_{ki}^t(o_{ki}^t) = \begin{cases} a; & \text{if } c_{ki}^t(o_{ki}) = 1 \\ 100 - a; & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (5)$$

With;

a = a random number greater than 50

By using above assumptions Vor_{ki}^t is defined as payoff that will be obtained by agent i at iteration t if its option k^{th} is rejected. The value of Vor_{ki}^t in the proposed mechanism is then assigned as follows:

$$Vor_{ki}^t: c_{ki}^t(o_{ki}^t) = \begin{cases} 100 - a; & \text{if } c_{ki}^t(o_{ki}) = 1 \\ a; & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (6)$$

With;

a = a random number greater than 50

Using equation (5) and (6), the payoff that will be obtained by agent i from its k^{th} option at iteration t can be defined as follows:

$$Vo_{ki}^t: c_{ki}^t(o_{ki}^t) = \begin{cases} Voa_{ki}^t: c_{ki}^t(o_{ki}^t); & \text{if } c_{ki}^t(o_{ki}) = 1 \\ Vor_{ki}^t: c_{ki}^t(o_{ki}^t); & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (7)$$

At every iteration t , agent i can choose to reject, accept, or indifferent toward option k of agent j . Let $Vpao_{kij}^t$ is agents i 's payoff in *accept dimension* generated by aget i 's position toward option k of agent j . The value of $Vpao_{kij}^t$ is assigned as follows:

$$Vpao_{kij}^t: c_{kij}^t(o_{kij}^t) = \begin{cases} a; & \text{if } c_{kij}^t(o_{kij}) = 1 \\ 50; & \text{if } c_{kij}^t(o_{kij}) = 0 \\ 100 - a; & \text{if } c_{kij}^t(o_{kij}) = -1 \end{cases} \quad (8)$$

With;

a = a random number greater than 50

Let $Vpor_{kij}^t$ is agents i 's payoff in *reject dimension* generated by aget i 's position toward option k of agent j . The value of $Vpor_{kij}^t$ is assigned as follows:

$$Vpor_{kij}^t: c_{kij}^t(o_{kij}^t) = \begin{cases} 100 - a; & \text{if } c_{kij}^t(o_{kij}) = 1 \\ 50; & \text{if } c_{kij}^t(o_{kij}) = 0 \\ a; & \text{if } c_{kij}^t(o_{kij}) = -1 \end{cases} \quad (9)$$

With;

a = a random number greater than 50

Therefore, the payoff that will be obtained by agent i from the k^{th} option of agent j at iteration t can be defined as follows:

$$Vpo_{kij}^t: c_{kij}^t(o_{kij}^t) = \begin{cases} Vpo_{kij}^t & \text{if } c_{kij}^t(o_{kij}) = 1 \\ 50; & \text{if } c_{kij}^t(o_{kij}) = 0 \\ Vpro_{kij}^t & \text{if } c_{kij}^t(o_{kij}) = -1 \end{cases} \quad (10)$$

Using equation (7) and (10), the total payoff that will be obtained by agent i if all of its positions are adopted by all agents at iteration t can be calculated as follows:

$$Vp_i^t(p_i^t) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad (11)$$

With;

m = number option and $i \neq j$.

In the other hand, if agent i adopt all agent j 's positions then, the total payoff that will be obtained by agent i can be calculated as follows:

$$Vpp_i^t(p_j^t) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad (12)$$

With;

m = number option and $i \neq j$.

In the implementation process payoffs that will be obtained by all agents in *accept dimension* are stored in *acc-payoff matrix* and payoffs in *reject dimension* are stored in *rej-payoff* matrix. In both matrices, the columns of the matrix represent agents and the rows of the matrix represent options. Using these matrices, the Vp_i^t and Vpp_i^t values of all agents are then calculated. The results are then stored in a matrix called *Vpo-matrix*. Element in column 1 and row 1 of *Vpo-matrix* represents the total payoff that will be obtained by agent 1 if it adopts its own positions (Vp_1) while, element in column 1 and row 2 of *Vpo-matrix* represents the total payoff that will be obtained by agent 1 if it adopts agent 2 positions (Vpp_1).

Exhibit 2

Using the conditions explained in Exhibit 1, the elements of acc-payoff and rej-payoff can be illustrated in Figures 10.

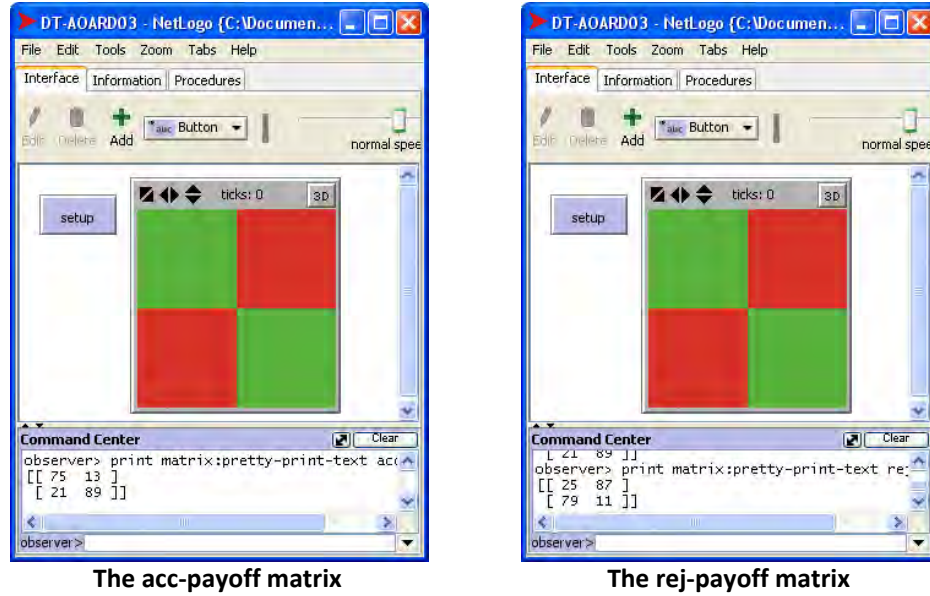


Figure 10 Illustration of implementation result of acc-payoff and rej-payoff matrices

In this Exhibit the total payoff that will be obtained by agent 1 if it adopts all of its positions is $75 + 79 = 154$, and the total payoff that will be obtained by agent 1 if it adopts all agent 2 positions is $25 + 21 = 46$. In the other hand, the total payoff that will be obtained by agent 2 if it adopts all of its positions is $87 + 89 = 176$, and the total payoff that will be obtained by agent 2 if it adopts all agent 1 positions is $13 + 11 = 24$.

Therefore, the resulting Vpo-matrix can be illustrated in Table 7.

Table 7 Illustration of the Vpo-matrix

	Agent 1	Agent 2
Agent 1	$V_{p_1} = 154$	$V_{pp_2} = 24$
Agent 2	$V_{pp_1} = 46$	$V_{p_2} = 176$

The implementation result of this process in NetLogo is illustrated in Figure 11.

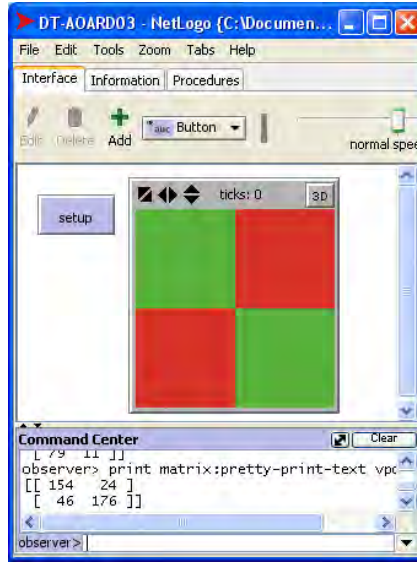


Figure 11 Illustration of implementation result of Vpo-matrix

Model of Agent's Perception toward Other's Payoff

In this study each agent is assumed to have estimation toward the payoff that will be obtained by other agents. At the beginning of the simulation, agent's estimation toward the other's payoff is assumed to be made based on positions taken by other agents. If agent j choose to accept an option then, agent i will estimates that for the given option agent j 's payoff in *accept dimension* will be greater than agent j 's payoff in *reject dimension* and vice versa. If agent j is indifferent toward an option then, agent i will estimates that for the given option agent j 's payoff in *accept dimension* will is equal to agent j 's payoff in *reject dimension*.

Using the above assumptions then it can be defined Voa_{kij}^{*t} as agent i 's estimation at iteration t , toward agent j 's payoff in *accept dimension* that is generated by agent j 's position toward option k that is owned by agent j .

$$Voa_{kij}^{*t}: c_{kj}^t(o_{kj}^t) = \begin{cases} a; & \text{if } c_{kj}^t(o_{kj}^t) = 1 \\ 100 - a; & \text{if } c_{kj}^t(o_{kj}^t) = -1 \end{cases} \quad (13)$$

With;

a = a random number greater than 50

Conversely, Vor_{kij}^{*t} is defined as agent i 's estimation at iteration t , toward agent j 's payoff in *reject dimension* that is generated by agent j 's position toward option k that is owned by agent j .

$$Vor_{kij}^{*t}: c_{kj}^t(o_{kj}^t) = \begin{cases} 100 - a; & \text{if } c_{kj}^t(o_{kj}) = 1 \\ a; & \text{if } c_{kj}^t(o_{kj}) = -1 \end{cases} \quad (14)$$

With;

a = a random number greater than 50

Therefore, agent i 's estimation toward agent j 's payoff that is generated by option k that is owned by agent j , can be calculated as follows:

$$Vo_{kij}^{*t}: c_{kj}^t(o_{kj}^t) = \begin{cases} Voa_{kij}^{*t}: c_{kj}^t(o_{kj}^t); & \text{if } c_{kj}^t(o_{kj}) = 1 \\ Vor_{kij}^{*t}: c_{kj}^t(o_{kj}^t); & \text{if } c_{kj}^t(o_{kj}) = -1 \end{cases} \quad (15)$$

At every iteration t , agent i will also estimate the payoff that will be obtained by agent j 's positions toward the other agent's options. Let $Vpoa_{kij}^{*t}$ is agents i 's estimation toward agent j 's payoff in *accept dimension* that is generated by agent j 's position toward option belong to agent i . The value of $Vpoa_{kij}^{*t}$ is assigned as follows:

$$Vpoa_{kij}^{*t}: c_{kji}^t(o_{kji}^t) = \begin{cases} a; & \text{if } c_{kji}^t(o_{kji}) = 1 \\ 50; & \text{if } c_{kji}^t(o_{kji}) = 0 \\ 100 - a; & \text{if } c_{kji}^t(o_{kji}) = -1 \end{cases} \quad (16)$$

With;

a = a random number greater than 50

Let $Vpor_{kij}^{*t}$ is agents i 's estimation toward agent j 's payoff in *reject dimension* generated by agent j 's position toward option k that are belong to agent i . The value of $Vpor_{kij}^{*t}$ is assigned as follows:

$$Vpor_{kij}^{*t}: c_{kji}^t(o_{kji}^t) = \begin{cases} 100 - a; & \text{if } c_{kji}^t(o_{kji}) = 1 \\ 50; & \text{if } c_{kji}^t(o_{kji}) = 0 \\ a; & \text{if } c_{kji}^t(o_{kji}) = -1 \end{cases} \quad (17)$$

With;

a = a random number greater than 50

Therefore, agent i 's estimation toward agent j 's payoffs that are generated by agent j 's positions toward other agent's options can be calculated as follows:

$$Vpo_{kij}^{*t}: c_{kji}^t(o_{kji}^t) = \begin{cases} Vpoa_{kji}^{*t} & \text{if } c_{kji}^t(o_{kji}) = 1 \\ 50; & \text{if } c_{kji}^t(o_{kji}) = 0 \\ Vpor_{kji}^{*t} & \text{if } c_{kji}^t(o_{kji}) = -1 \end{cases} \quad (18)$$

Using equation (15) and (18), agent i 's estimation the total payoff of agent j 's by adopting all agent j 's positions at iteration t can be calculated as follows:

$$Vp_{ij}^{*t}(p_j^t) = Vo_{kij}^{*t} + \sum_m Vpo_{kij}^{*t} \quad (19)$$

With;

m = number option and $i \neq j$.

In the other hand, agent i 's estimation toward agent j 's total payoff if agent j adopt all agent i 's positions then can be calculated as follows:

$$Vpp_{ij}^{*t}(p_i^t) = Vo_{kij}^{*t} + \sum_m Vpo_{kij}^{*t} \quad (20)$$

With;

m = number option and $i \neq j$.

In the implementation process, agent i 's estimation toward other agent's payoffs in *accept dimension* are stored in *per-acc-payoff-i matrix* and agent i 's estimation toward other agent's payoffs in *reject dimension* are stored in *per-rej-payoff-i matrix*. The columns of these matrices represent agents and the rows of the matrix represent options. All elements in the column that corresponds agent i , are set as zero.

Exhibit 3

Using conditions that was described in Exhibit 1, the per-acc-payoff-1 matrix and the per-acc-payoff-2 matrix in NetLogo is described in Figure 12.

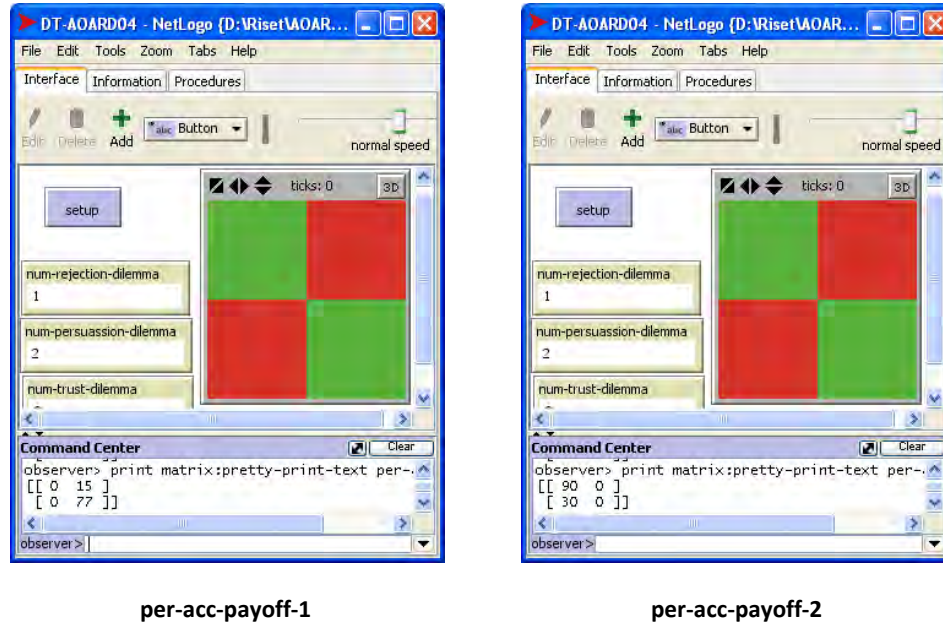


Figure 12 Illustration of per-acc-payoff-1 and per-acc-payoff-2

While, the Figure 13 describes the implementation results of per-rej-payoff-1 matrix and the per-rej-payoff-2 matrix in NetLogo:

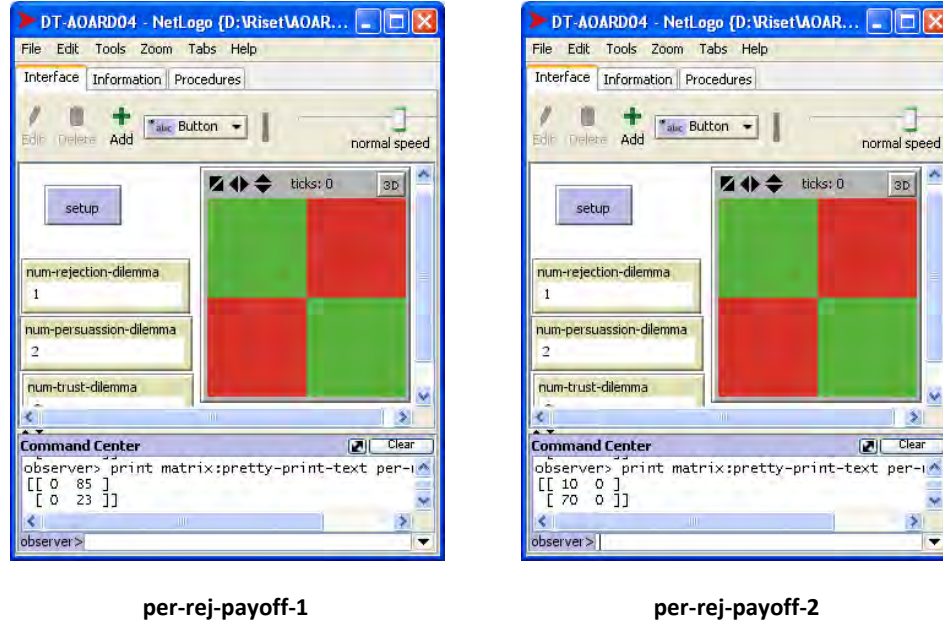


Figure 13 Illustration of per-acc-payoff-1 and per-acc-payoff-2

Using these matrices, agent 1's estimation toward agent 2's total payoff if agent 2 is adopting its own positions (Vp_{12}^*) is $85 + 77 = 162$. While, agent 1's estimation toward agent 2's total payoff if agent 2 is adopting agent 1's positions (Vpp_{12}^*) is $15 + 23 = 38$. In the other side, agent 2's estimation toward agent 1's total payoff if agent 1 is adopting its own positions (Vp_{21}^*) is $90 + 70 = 160$. While, agent 2's estimation toward agent 1's total payoff if agent 1 is adopting agent 2's positions (Vpp_{21}^*) is $10 + 30 = 40$.

Model of Threat

For each option O_{ik} that is owned by agent i , agent i has a threatened position t_i (O_{ik}). Threatened positions of all agents will construct a threat vector that is described as follows:

$$t = \{t_1, t_2, t_3, \dots, t_n\} \quad (21)$$

With;
n = number of agent

This threat vector will generates payoff for each agent if all agents carry out their threatened future. Let Vp_i^t is the total payoff of agent i if the threatened future is adopted. The value of Vp_i^t can be calculated as follows.

$$Vpt_i^t(t) = Vo_{ki} + \sum_m Vpo_{kij}^t \quad (22)$$

With;
m = number option and $i \neq j$.

In the proposed model, threats of each agent serve as inputs in the form of array that is called as *threat vector*. Each element in this array represents an option. The total payoff for each agent that is calculated using the *threat vector* is stored as an array called *Vpt-vector*. Each element in this array represents the total payoff obtained by each agent.

Exhibit 4

Suppose in Exhibit 1 the threat of agent 1 is to accept option O_{11} and the threat of agent 2 is to accept option O_{12} , then the input vector for the simulation can be described as follows:

$$[1 \quad 1] \quad (23)$$

The first element of this array represents option O_{11} and the second element of this array represents option O_{12} . Suppose the acc-payoff and the rej-payoff matrices in the simulation are as described in Figure 14.

```

Command Center
observer> print matrix:pretty-print-text acc-payoff
[[ 61  49 ]
 [  7  59 ]]
observer> print matrix:pretty-print-text rej-payoff
[[ 39  51 ]
 [ 93  41 ]]
observer>

```

Figure 14 Illustration of acc-payoff and rej-payoff matrices

Then, using threat vector described in equation (23) the total payoff for agent 1 if the treated future is adopted (Vpt_1^t) is $61 + 7 = 68$. While, the total payoff for agent 2 if the treated future is adopted (Vpt_2^t) is $49 + 59 = 108$. The Vpt-vector result in this exhibit can be described in Figure 15.

```

Command Center
observer> print matrix:pretty-print-text rej-payoff
[[ 39  51 ]
 [ 93  41 ]]
observer> print matrix:pretty-print-text Vpt-vector
observer> show Vpt-vector
observer: [68 108]
observer>

```

Figure 15 Illustration of Vpt-vector

Model of Confrontation Dilemmas

This study assumes that every iteration each agent will calculate its confrontations dilemmas toward the other agents. This study addresses two types of confrontation dilemmas *i.e.* persuasion and rejection dilemmas. By using the definition that has been discussed in theoretical backgrounds, in the proposed mechanism both of these dilemmas can be defined as follows:

- Agent i faces rejection dilemma toward agent j when the total payoff that will be obtained by agent i by adopting the threatened futures is less than or equal to the total payoff that will be obtained by agent i by adopting agent j 's position. In the proposed mechanism, this kind of dilemma will occur if $Vpt_i^t \leq Vpp_i^t$.
- Agent i faces persuasion dilemma toward agent j when the total payoff that will be obtained by agent j by adopting the threatened futures is greater than the total payoff that will be obtained by agent j by adopting agent i 's position. In the proposed mechanism, this kind of dilemma will occur if $Vpp_j^t \leq Vpt_j^t$.

Exhibit 5

Consider the agent's positions explained in the Exhibit 1 and threat vector explained in Exhibit 4, the *Vpo matrix* and *Vpt vector* are as follow:

Table 8 Illustration of Vpo matrix and Vpt vector used to calculate confrontation dilemmas

Vpo Matrix			Vpt vector
	Agent 1	Agent 2	
Agent 1	$Vp_1 = 184$	$Vpp_2 = 74$	[98 74]
Agent 2	$Vpp_1 = 16$	$Vp_2 = 126$	

Based on Table 8 agent 1 will face persuasion dilemma toward agent 2 because agent 2's total payoff to adopt the threatened future is equal to agent 2's total payoff to adopt agent 1's position ($74 \leq 74$). In the other hand, agent 2 will face rejection dilemma toward agent 1 because agent 2's total payoff to adopt agent 1's position is equal to agent 2's total payoff to adopt the threatened future. The Implementation result in NetLogo is shown in Figure 16.

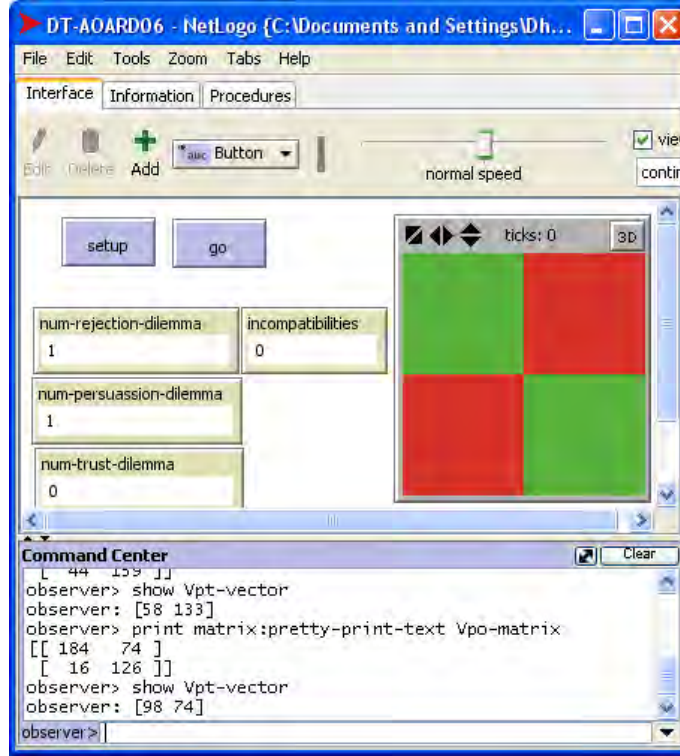


Figure 16 Implementation result of confrontation dilemma calculation

Model of Collaboration Dilemmas

In this study, it is assumed that after all agent's positions become compatible; agents will calculate their collaboration dilemmas toward the other agents. The collaboration dilemma that is considered in this research is the trust dilemma. In this study it is assumed that the trust dilemma will arise as a result of misperception among agents.

In the proposed mechanism agent i will have trust dilemma toward agent j if agent i 's estimation toward agent j 's payoff for a certain position is contrary to the position that is declared by agent j . For example, collaboration dilemma will occur if agent j is accepting option k while agent i 's estimation toward agent j 's payoff by accepting option k is less than 50. Generally the trust dilemmas will occur if:

$$c_{kj}^t(o_{kj}) = 1 \text{ but } Voa_{kij}^{*t} < Vor_{kij}^{*t} \quad (24.a)$$

Or

$$c_{kj}^t(o_{kj}) = -1 \text{ but } Vor_{kij}^{*t} < Voa_{kij}^{*t} \quad (24.b)$$

Or

$$c_{kji}^t(o_{ki}) = 1 \text{ but } Vpoa_{kij}^{*t} < Vpor_{kij}^{*t} \quad (24.c)$$

Or

$$c_{kji}^t(o_{ki}) = -1 \text{ but } Vpor_{kij}^{*t} < Vpoa_{kij}^{*t} \quad (24.d)$$

Exhibit 6

Suppose there are two agents who each have one option, with the position described in Table 9.

Table 9 Agent's positions

	Agent 1	Agent 2
O ₁₁	C ₁₁ : accept	C ₁₁₂ : indifferent
O ₁₂	C ₁₂₁ : accept	C ₁₂ : accept

Agent 1's estimation toward agent 2's payoff in *accept* and *reject* dimension are described in Figure 17.

```

Command Center
observer> print matrix:pretty-print-text per-acc-payoff1
[[ 0 76.5 ]
 [ 0 64.5 ]]
observer> print matrix:pretty-print-text per-rej-payoff1
[[ 0 23.5 ]
 [ 0 35.5 ]]
observer>

```

Figure 17 Agent 1's estimation toward agent 2's payoff

While, agent 2's estimation toward agent 1's payoff in accept and reject dimension are described in Figure 18.

```

Command Center
observer> print matrix:pretty-print-text per-acc-payoff2
[[ 26 0 ]
 [ 21 0 ]]
observer> print matrix:pretty-print-text per-rej-payoff2
[[ 74 0 ]
 [ 79 0 ]]
observer>

```

Figure 18 Agent 2's estimation toward agent 1's payoff

In this exhibit agent 2 faces trust dilemmas toward agent 1 because agent 1's is accepting option O₁₁ and O₁₂ while, agent 2's estimation toward agent 1's payoff in accept dimension for both options is less than agent 2's estimation toward

agent 1's payoff in reject dimension for both options ($26 < 74$ and $21 < 79$). The implementation result in NetLogo is shown in Figure 19.

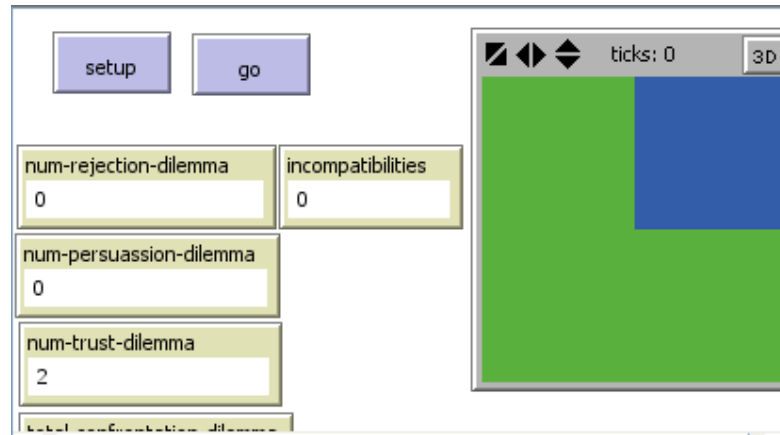


Figure 19 Trust dilemma implementation in NetLogo

Model of Agent's Emotion

In this study each agent is assumed to have the emotions toward the other agents. Agent's emotion towards the other agents consists of three dimensions *i.e.* pleasure, arousal and dominance. Each dimension of agent emotion can be described in a matrix thus there are three matrices called pleasure-matrix, arousal-matrix and dominance-matrix. These matrices columns represent i while the rows represent agent j . Therefore, in these matrices element p_{12} of pleasure-matrix represents agent 1's pleasure toward agent 2, element p_{21} of pleasure-matrix represents agent 2's pleasure toward agent 1 and so on. While, agent's emotion toward itself *i.e.* the diagonal of each matrix, is set as zero. In the implementation process, the three matrices are used as input for the proposed mechanism.

By using these matrices, the emotional state of each agent toward the other agents can be calculated as follows (Jiang, 2007):

$$Se_{ij} = p_{ij} * (1 + a_{ij}) - d_{ij} \quad (25)$$

Exhibit 7

Using conditions explained in Exhibit 1, suppose the pleasure-matrix, arousal-matrix and dominance-matrix inputs are as follow:

$$\begin{array}{ccc}
\text{Pleasure-matrix} & \text{arousal-matrix} & \text{dominance-matrix} \\
\begin{bmatrix} 0 & 0.5 \\ 1 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0.5 \\ 1 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0.5 \\ 1 & 0 \end{bmatrix}
\end{array} \quad (26)$$

Using the above matrices the emotional state of agent 1 toward agent 2 is $Se_{12} = 1 (1 + 1) - 1 = 1$. While, the emotional state of agent 2 toward agent 1 is $Se_{21} = 0.5 (1 + 0.5) - 0.5 = 0.25$. The implementation result in NetLogo is shown in Figure 20.

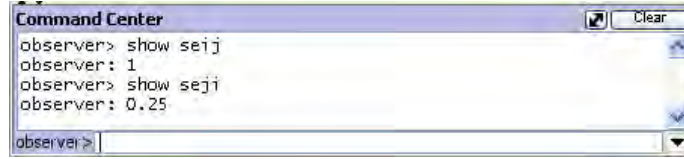


Figure 20 Agent's emotional state calculation

Model of Negotiation Protocol

In this study, agents are assumed to negotiate each other using rational negotiation approach in which, an agent will sacrifice some of its payoff in order to shift its opponent's positions. In each iteration $t = \{t_1, t_2, t_3 \dots t_n\}$ agent i and agent j will negotiate each other if there are dilemmas among them. From the present position p_i^{t-1} and p_j^{t-1} agent i and agent j will negotiate options in which they have incompatible positions (agent i accept and agent j reject or vice versa). Agent i will gives offer to agent j using strategy (St) and emotional state (Se_{ij}) with value:

$$Ov_{ij}^t = Se_{ij} * St_i + St_i \quad (27)$$

With;

St_i = agent i 's strategy is a random number between 0 and 10

This equation shows how much the effect of negotiation conducted by agent i toward the shift of agent i 's payoff. The value of strategy St_i will reduce agent i 's payoff in the dimension that is chosen by agent i and increase agent i 's payoff in the dimension that is not chosen by agent i . Thus, after giving offer to agent j , element of agent i 's payoff in *accept dimension* will change as follow:

$$Voa_{ki}^t = \begin{cases} Voa_{ki}^{t-1} - St_i; & \text{if } c_{ki}^t(o_{ki}) = 1 \\ Voa_{ki}^{t-1} + St_i; & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (28)$$

While element of agent i 's payoff in *reject dimension* will change as follow:

$$Vor_{ki}^t = \begin{cases} Vor_{ki}^{t-1} + St_i; & \text{if } c_{ki}^t(o_{ki}) = 1 \\ Vor_{ki}^{t-1} - St_i; & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (29)$$

Rules described in equation (28) and (29) also apply when agent i is negotiating options belong to other agents.

After agent i give offer to agent j , agent i 's estimation toward agent j 's payoff will change. The value of strategy St_i will reduce agent i 's estimation toward agent j 's payoff in the dimension that is chosen by agent j and increase agent i 's estimation toward agent j 's payoff in the dimension that is not chosen by agent j . Thus, after giving an offer to agent j , element of agent i 's estimation toward agent j 's payoff in *accept dimension* will change as follow:

$$Voa_{kij}^{*t} = \begin{cases} Voa_{kij}^{*t-1} - St_i; & \text{if } c_{kj}^t(o_{ki}) = 1 \\ Voa_{kij}^{*t-1} + St_i; & \text{if } c_{kj}^t(o_{ki}) = -1 \end{cases} \quad (30)$$

While element of agent i 's estimation toward agent j 's payoff in *reject dimension* will change as follow:

$$Vor_{kij}^{*t} = \begin{cases} Vor_{kij}^{*t-1} + St_i; & \text{if } c_{kj}^t(o_{ki}) = 1 \\ Vor_{kij}^{*t-1} - St_i; & \text{if } c_{kj}^t(o_{ki}) = -1 \end{cases} \quad (31)$$

Rules described in equation (30) and (31) also apply when agent i is negotiating options belong to other agents.

After receiving agent i 's offer, agent j with emotional state Se_{ji} will then perceives agent i 's offer as follows:

$$Ov_{ji}^t = Se_{ji} * Ov_{ij}^t + Ov_{ij}^t \quad (32)$$

Agent j 's perception toward agent i 's offer will then reduce agent j 's payoff in the dimension that is chosen by agent j and increase agent j 's payoff in the dimension that is not chosen by agent j . Thus, after receiving offer from agent i , element of agent j 's payoff in *accept dimension* will change as follow:

$$Voa_{kj}^t = \begin{cases} Voa_{kj}^{t-1} + Ov_{ji}^t; & \text{if } c_{kj}^t(o_{ki}) = 1 \\ Voa_{kj}^{t-1} - Ov_{ji}^t; & \text{if } c_{kj}^t(o_{ki}) = -1 \end{cases} \quad (33)$$

While element of agent j 's payoff in *reject dimension* will change as follow:

$$Vor_{kj}^t = \begin{cases} Vor_{kj}^{t-1} + Ov_{ji}^t; & \text{if } c_{kj}^t(o_{ki}) = 1 \\ Vor_{kj}^{t-1} - Ov_{ji}^t; & \text{if } c_{kj}^t(o_{ki}) = -1 \end{cases} \quad (34)$$

Rules described in equation (33) and (34) also apply when agent i is negotiating options belong to other agents.

Agent j 's perception toward agent i 's offer will also affect agent j 's estimation toward agent i 's payoff. It will reduce agent j 's estimation toward agent i 's payoff in the dimension that is chosen by agent i and increase agent j 's estimation toward agent i 's payoff in the dimension that is not chosen by agent i . Thus, after receiving offer from agent i , element of agent j 's estimation toward agent i 's payoff in *accept dimension* will change as follow:

$$Voa_{kji}^{*t} = \begin{cases} Voa_{kji}^{*t-1} - Ov_{ji}; & \text{if } c_{ki}^t(o_{ki}) = 1 \\ Voa_{kji}^{*t-1} + Ov_{ji}; & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (35)$$

While element of agent j 's estimation toward agent i 's payoff in *reject dimension* will change as follow:

$$Vor_{kji}^{*t} = \begin{cases} Vor_{kji}^{*t-1} + Ov_{ji}; & \text{if } c_{ki}^t(o_{ki}) = 1 \\ Vor_{kji}^{*t-1} - Ov_{ji}; & \text{if } c_{ki}^t(o_{ki}) = -1 \end{cases} \quad (36)$$

Rules described in equation (35) and (36) also apply when agent i is negotiating options belong to other agents.

Exhibit 8

Suppose there are two agents with options that are explained in Exhibit 1. The payoffs of both agents in accept and reject dimensions are described in Figure 21.

```

Command Center
observer> print matrix:pretty-print-text acc-payoff
[[ 91  6 ]
 [ 35 99 ]]
observer> print matrix:pretty-print-text rej-payoff
[[ 9 94 ]
 [ 65 1 ]]
observer>

```

Figure 21 Agent's acc-payoff and rej-payoff

Agent 1's estimation toward agent 2's payoffs in *accept* and *reject* dimension are described in Figure 22.

```

Command Center
observer> print matrix:pretty-print-text per-acc-payoff1
[[ 0 36 ]
 [ 0 99 ]]
observer> print matrix:pretty-print-text per-rej-payoff1
[[ 0 64 ]
 [ 0 1 ]]
observer>

```

Figure 22 Agent 1's estimation toward agent 2's payoff

While, agent 2's perception toward agent 1's payoffs in accept and reject dimension are described in Figure 23.

```

Command Center
observer> print matrix:pretty-print-text per-acc-payoff2
[[ 89 0 ]
 [ 33 0 ]]
observer> print matrix:pretty-print-text per-rej-payoff2
[[ 11 0 ]
 [ 67 0 ]]
observer>

```

Figure 23 Agent 2's estimation toward agent 1's payoff

The pleasure, arousal and dominance dimension of each agent are described in Figure 24.

```

Command Center
observer> print matrix:pretty-print-text pleasure-matrix
[[ 0 1 ]
 [ 0.5 0 ]]
observer> print matrix:pretty-print-text arousal-matrix
[[ 0 1 ]
 [ 0.5 0 ]]
observer> print matrix:pretty-print-text dominance-matrix
[[ 0 1 ]
 [ 0.5 0 ]]
observer>

```

Figure 24 Pleasure, arousal and dominance dimension of each agent

By using the positions that have been explained in Exhibit 1, then in the first round of negotiation, agent 1 and agent 2 have incompatible position in option O_{11} , which is accepted by agent 1 and is rejected by agent 2. Agent 1 has the first opportunity to give offer to agent 2. By using emotion matrices in Figure 24, then in the first round of negotiation agent 1's emotional state toward agent 2 (Se_{ij}) and agent 2's emotional state toward agent 1 (Se_{ji}) are as follows.

```

Command Center
"seij"0.25
"seji"1
observer>

```

Agent 1 will then give offer to agent 2. Suppose the strategy used by agent 1 is equal to 1. Since agent 1 is accepting option O_{11} then agent 1's apayoff will change from 91 to $91 - 1 = 90$ in accept dimension and from 9 to $9 + 1 = 10$ in reject dimension. The new payoff matrices of agent 1 after it gives offer to agent 2 are described in Figure 25.

```

Command Center
acc-payoff
[[ 90 6 ]
 [ 35 99 ]]
rej-payoff
[[ 10 94 ]
 [ 65 1 ]]
observer>

```

Figure 25 Agent 1's payoff matrices after giving option to agent 2

After giving offer to agent 2, agent 1's estimation toward agent 2's payoff in accept and reject dimension is change. Agent 1 estimates that agent 2's, who is rejecting option O_{11} , payoff changes from 36 to $36 + 1 = 37$ in accept dimension and from 64 to $64 - 1 = 63$ in reject dimension. The new agent 1's estimation toward agent 2 payoff is described in Figure 26.



Figure 26 Agent 1's new estimation toward agent 2's payoff

Using emotional state $Se_{ij} = 0.25$ and strategy = 1, agent 1's negotiation effect toward the shift of agent 2's position is $Ov_{ij} = 0.25 * 1 + 1 = 1.25$. Using emotional state $Se_{ji} = 1$, agent 2 perceives agent 1's offer as $Ov_{ji} = 1 * 1.25 + 1.25 = 2.5$. Agent 2's perception toward agent 1's offer will change agent 2's, who is rejecting option O_{11} , payoff in accept dimension from 6 to $6 + 2.5 = 8.5$ and agent 2's payoff in reject dimension from 94 to $94 - 2.5 = 91.5$. The new payoff matrices after this process are described in Figure 27.



Figure 27 Agent 2's payoff matrices after receiving option from agent 1

After receiving offer from agent 1, agent 2's estimation toward agent 1's payoff in *accept* and *reject* dimension is change. Agent 2 estimates that agent 1's, who is accepting option O_{11} , payoff changes from 89 to $89 - 2.5 = 86.5$ in accept dimension and from 11 to $11 + 2.5 = 13.5$ in reject dimension. The new agent 2's estimation toward agent 1 payoff is described in Figure 28.



Figure 28 Agent 2's new estimation toward agent 1's payoff

Model of Emotion Dynamics

After agent i give offer to agent j , agent i will evaluate agent j 's response toward its offer. Agent j 's response will affect agent i 's emotional state toward agent j in the next iteration. To model the dynamics of agent's emotional state, this research adopts the Flow Model of Emotion concept (Morgado & Gaspar, 2003).

In Flow Model of Emotion concept, there are factors that affect the dynamics of emotional state that are:

1. Achievement potential (p), which describes the potential magnitude of change that can be done by agents to the environment in order to achieve the desired conditions. Because in the drama theory framework the desired condition is the dilemma-free condition, and this condition will be achieved by negotiations among agents, potential achievement owned by agent i at every negotiation is assumed to be proportional to the offer that is given by agent i (Ov_{ij}).
2. Achievement conductive (q), which describes the level of conductivity (facilitating, receiving) and resistivity (block, reject) from the environment to the changes proposed by an agent. In this study the resistance experienced by the agent i is assumed to be proportional to the perception of agent j toward agent i 's offer (Ov_{ji}).

Using the above definitions the emotional disposition can be defined as:

$$ED = \langle \partial Ov_{ij}, \partial Ov_{ji} \rangle = \left\langle \frac{dOv_{ij}}{dt}, \frac{dOv_{ji}}{dt} \right\rangle \quad (37)$$

The possible combination of ∂Ov_{ij} and ∂Ov_{ji} is related with the feelings experienced by the agents in the real world that are resulted by the negotiation outcomes. Unfortunately, although it can describe the emotional condition numerically, the PAD model does not map the feelings experienced by the agent into the emotional state. To overcome this problem the Ortony, Clore, Collins (Ortony, Clore, & Collins, 1988) emotion model is adopted. OCC model can facilitate the classification of emotional state based on the feelings experienced by the agent, but cannot describe it numerically therefore the OCC is needs to be mapped back to PAD model (Gebhard, 2005). The mapping process is described in Table 10.

Table 10 Transformation from emotional disposition into PAD dimensions

Emotional Disposition	Feelings	OCC	PAD		
			r_p	r_a	r_d
$\partial Ov_{ij} > 0 \ \& \ \partial Ov_{ji} > 0$	Hoped for good thing and it happend	Satisfy, joy	+	+	+
$\partial Ov_{ij} > 0 \ \& \ \partial Ov_{ji} < 0$	Other's Blameworthy act	Anger	-	+	+
$\partial Ov_{ij} < 0 \ \& \ \partial Ov_{ji} > 0$	Other's praiseworthy act	Gratitude	+	+	-
$\partial Ov_{ij} < 0 \ \& \ \partial Ov_{ji} < 0$	Self initiated blameworthy act	Fear confirmed	-	-	-

From Table 10 the change in pleasure, arousal and dominance due to the changes in Ov_{ij} and Ov_{ji} can be identified but, the magnitude of the emotional disposition can only be identified through measurements. Therefore, in this simulation the magnitude of emotional disposition is assigned as a random number. In each negotiation agent i 's emotional state will change as follow:

$$p_{ij}^t = \begin{cases} p_{ij}^{t-1} + \text{random}[0, (1 - p_{ij}^{t-1})] & \text{If } Ov_{ij}^t > Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t > Ov_{ji}^{t-1} \\ p_{ij}^{t-1} + \text{random}[0, (-1 - p_{ij}^{t-1})] & \text{If } Ov_{ij}^t > Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t < Ov_{ji}^{t-1} \\ p_{ij}^{t-1} + \text{random}[0, (1 - p_{ij}^{t-1})] & \text{If } Ov_{ij}^t < Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t > Ov_{ji}^{t-1} \\ p_{ij}^{t-1} + \text{random}[0, (-1 - p_{ij}^{t-1})] & \text{If } Ov_{ij}^t < Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t < Ov_{ji}^{t-1} \end{cases} \quad (38.a)$$

$$a_{ij}^t = \begin{cases} a_{ij}^{t-1} + \text{random}[0, (1 - a_{ij}^{t-1})] & \text{If } Ov_{ij}^t > Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t > Ov_{ji}^{t-1} \\ a_{ij}^{t-1} + \text{random}[0, (1 - a_{ij}^{t-1})] & \text{If } Ov_{ij}^t > Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t < Ov_{ji}^{t-1} \\ a_{ij}^{t-1} + \text{random}[0, (1 - a_{ij}^{t-1})] & \text{If } Ov_{ij}^t < Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t > Ov_{ji}^{t-1} \\ a_{ij}^{t-1} + \text{random}[0, (-1 - a_{ij}^{t-1})] & \text{If } Ov_{ij}^t < Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t < Ov_{ji}^{t-1} \end{cases} \quad (38.b)$$

$$d_{ij}^t = \begin{cases} d_{ij}^{t-1} + \text{random}[0, (1 - d_{ij}^{t-1})] & \text{If } Ov_{ij}^t > Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t > Ov_{ji}^{t-1} \\ d_{ij}^{t-1} + \text{random}[0, (1 - d_{ij}^{t-1})] & \text{If } Ov_{ij}^t > Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t < Ov_{ji}^{t-1} \\ d_{ij}^{t-1} + \text{random}[0, (-1 - d_{ij}^{t-1})] & \text{If } Ov_{ij}^t < Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t > Ov_{ji}^{t-1} \\ d_{ij}^{t-1} + \text{random}[0, (-1 - d_{ij}^{t-1})] & \text{If } Ov_{ij}^t < Ov_{ij}^{t-1} \text{ AND } Ov_{ji}^t < Ov_{ji}^{t-1} \end{cases} \quad (38.c)$$

Exhibit 9

Consider the interaction in Exhibit 8 is the first negotiation round such that, the offer made by agent 1 to agent 2 regarding option O_{11} in the previous negotiation and, perception of agent 2 toward agent 1's offer regarding option O_{11} in the previous negotiation are zero. Under this circumstance, the pleasure, arousal, and dominance of agent 1 toward agent 2 should increase since

$Ov_{12}^1 > Ov_{12}^0$ and $Ov_{21}^1 > Ov_{21}^0$. The implementation result in NetLogo is shown in Figure 29.

```

Command Center
"max-pleasure" [0.5 0]
"max-arousal" [0.5 0]
"max-dominance" [0.5 0]
"pleasure-matrix" [[
[ 0.5298315169260571 0 ]]
"arousal-matrix" [[
[ 0.8594089163449681 0 ]]
"dominance-matrix" [[
[ 0.947240356420053 0 ]]
"seij" 0.032033090312832536
observer>

```

Figure 29 Agent 1's emotion matrices after giving offer to agent 2

Learning Algorithm

This study assumes that agents are able to learn and determine the best emotion to be used in order to shift their opponent's positions. The main assumption this learning algorithm is that agents will identify the best emotional state based on their experience in the previous negotiation.

At the beginning of the simulation three matrices, called $BestOv_{ji}$; $Best\text{-}pleasure_{ij}$; $Best\text{-}arousal_{ij}$; and $Best\text{-}dominance_{ij}$ are defined. The columns of these matrices represent agent i while, the rows represent agent j . All elements in these matrices are initiated as zero. Of all the negotiations carried out by the agent i at each iteration agent i memorizes Ov_{ji}^t . Ov_{ji}^t is considered as payoff that is produced by a certain emotional state. Agent i then will sort all Ov_{ji}^t and identify $Max\text{-}Ov_{ji}^t$, $Max\text{-}pleasure$, $Max\text{-}arousal$, and $Max\text{-}dominance$ that indicate the maximum payoff at iteration t and the components of emotional state that produce it.

$$maxp^t = \begin{cases} p_{ij}^t & \text{if } MaxOv_{ij}^t > MaxOv_{ij}^{t-1} \\ maxp^{t-1} & \text{if } MaxOv_{ij}^t \leq MaxOv_{ij}^{t-1} \end{cases} \quad (39.a)$$

$$maxa^t = \begin{cases} a_{ij}^t & \text{if } MaxOv_{ij}^t > MaxOv_{ij}^{t-1} \\ maxa^{t-1} & \text{if } MaxOv_{ij}^t \leq MaxOv_{ij}^{t-1} \end{cases} \quad (39.b)$$

$$maxd^t = \begin{cases} d_{ij}^t & \text{if } MaxOv_{ij}^t > MaxOv_{ij}^{t-1} \\ maxd^{t-1} & \text{if } MaxOv_{ij}^t \leq MaxOv_{ij}^{t-1} \end{cases} \quad (39.c)$$

Based on experience its experience in ten iterations, agent i will revise the emotional state it used toward the other agents. Agent i will change the its emotional state with the best-pleasure, best-best-arousal and dominance, which is defined as the emotional state that generate maximum shift in other agent's position in ten iteration.

EXPERIMENTS

In this study four experiments are conducted. The first experiment aims to examine the model sensitivity to the variations agents' emotion. This experiment was designed to answer two questions. The first question is whether the variation of agents' emotion has impacts on the number of iterations required to eliminate confrontation dilemmas and the number of trust dilemma that arise at the end of the conflict. The second question is whether the answer of the first question also applies to the other conflict situations. To answer the second question the results obtained from the first scenario and from the second scenario are compared.

The second and third experiments aim to test the model's feasibility in describing the trend of agent's emotion and the majority of agent's positions that may appear. The model is considered to be feasible if its predictions regarding the trend of agent's emotion and the majority of agent's positions are valid generally. Since this model is initiated with arbitrary inputs gathered from observation data then the model is expected to produce prediction type 1 and/or type 2, with accuracy level 1. By assuming that the observed pattern in the real world as a subset of all possible pattern, in this study the model is considered to be valid if at least one of simulation results can mimic the pattern in the real world.

The meaning of feasible in this study is that the proposed models can be used to assist agents in the real world in facing conflict situation. Feasible and valid have overlapping meanings. Generally, valid means something that can be accepted as legitimately and logically (WrodNet Search 3.1; Wikitionary.org) while; feasible means something that is capable of being done with means at hand and circumstances as they are (WrodNet Search 3.1; Wikitionary.org). Not all valid solutions /answers are feasible to be used. But all answers/solutions that are produced by something that is feasible must able to satisfy all constraint (valid answer) (Wikipedia.org). With this understanding, the proposed model will be considered as feasible to be used if the model can produce valid solutions in all cases tested in the experiment. Model's feasibility is tested by comparing the experiment results from the first scenario and the second scenario in each experiment. If the model is valid for more than one scenario then it is feasible to be used in describing the trend of agent's emotion and the majority of agent's positions that may appear and therefore, it can be used to give recommendation for the decision makers in the real world.

In the fourth experiment, recommendations that can be proposed to the agents in Citarum River basin conflict are explored. By using the latest conflict situation, emotions that should be used by agents in order to obtain conflict's resolution that can help to improve the condition of the Citarum River are examined.

Experiment 1: Testing the Sensitivity of Proposed Model

The purpose of the experiments in this section is to test the sensitivity of the proposed model's behavior due to the variation of emotion emotions. This is important in order to test whether the dynamics exhibited by the model are actually caused by the variations in input parameters or simply merely the effects of the random nature of some modules in this model.

To conduct the sensitivity analysis, two test groups are set for each scenario. In the first test group, all values of pleasure, arousal and dominance dimension of all agents are initiated as 1 so; all agents in this test group have a positive emotional state toward other agents. In the second test group, all values of pleasure, arousal and dominance dimension of all agents are initiated as -1 so; all agents in this test group have a negative emotional state toward other agents.

In the both test group, agent's positions are initiated according to the common reference frame before 2008 for the first scenario and before 2009 for the first scenario. Other required parameters are initiated randomly. In each scenario each test group consisted of 30 simulation runs. In each run the number of iterations required to eliminate confrontation dilemmas and the number of trust dilemma at the end of simulation are recorded.

Sensitivity analysis Scenario 1

By using a common reference frame before 2008 as the initial position, the data obtained from 30 simulation runs are tabulated in Table 11.

Table 11 Simulation outputs from both test groups in Scenario 1

No	Goup 1		Group 2	
	iteration	trust	iteration	trust
1	27	41	45	47
2	34	52	63	50
3	37	42	48	44
4	27	37	37	45
5	29	40	70	50
6	42	38	31	44
7	31	45	89	45
8	27	37	46	48
9	39	39	63	51
10	35	56	56	42
11	29	34	39	53
12	28	32	70	47
13	18	42	43	43
14	48	31	48	52
15	43	46	89	47

No	Goup 1		Group 2	
	iteration	trust	iteration	trust
16	40	43	37	50
17	15	44	43	52
18	17	43	27	45
19	62	37	78	46
20	26	37	34	50
21	28	29	43	54
22	15	35	87	50
23	26	47	54	43
24	22	33	84	49
25	20	33	46	52
26	28	31	76	50
27	33	36	61	43
28	52	36	57	45
29	35	46	49	42
30	22	37	56	46

By assuming a run is comparable to a sample hypothesis testing is performed to test the sensitivity of the proposed model. The first step in the hypothesis testing is to test whether the simulation outputs are normally distributed. The null hypothesis for the test of normality states that the actual distribution of the

variable is equal to the expected distribution, *i.e.*, the variable is normally distributed. Since the sample size was less than 50, the Shapiro-Wilk statistic is used.

In Scenario 1 the result of test of normality for group 1 is described in Table 12.

Table 12 the test result for normality of group 1 outputs in Scenario 1

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Iteration	.145	30	.107	.947	30	.142
Trust	.142	30	.127	.961	30	.331

Based on Table 12 the Shapiro-Wilk test significance of iterations and trust variables are greater than 5% ($0.142 > 0.05$ and $0.331 > 0.05$). Thus, by using 95% level of confidence it can be concluded that the null hypothesis is accepted *i.e.* both the number of iterations required to eliminate confrontation dilemmas and the number of trust dilemma in group 1 of Scenario 1 are normally distributed.

The result of test of normality for group 2 from Scenario 1 is described in Table 13.

Table 13 the test result for normality of group 2 outputs in Scenario 1

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Iteration	.145	30	.111	.942	30	.102
Trust	.161	30	.047	.946	30	.131

Based on Table 13 the Shapiro-Wilk test significance of iterations and trust variables are greater than 5% ($0.102 > 0.05$ and $0.131 > 0.05$). Thus, by using 95% level confidence it can be concluded that the null hypothesis is accepted *i.e.* both the number of iterations required to eliminate confrontation dilemmas and the number of trust dilemma in group 2 of Scenario 1 are normally distributed.

After the normality of the outputs from both groups was tested, independent sample T-test is performed to examine whether there are significant differences between these two groups. The null hypotheses for the independent sample T test are:

$$H_{01}: \mu_{iteration1} = \mu_{iteration2}$$

$$H_{02}: \mu_{trust1} = \mu_{trust2}$$

The results of independent sample T-test in Scenario 1 is described in Table 14.

Table 14 The independent sample T test result of Scenario 1

		Independent Samples Test								
		Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Interval of the	
Iteration	Equal variances assumed	8.187	.006	-6.388	58	.000	-24.46667	3.83018	-32.13360	-16.79973
	Equal variances not assumed			-6.388	48.031	.000	-24.46667	3.83018	-32.16763	-16.76570
Trust	Equal variances assumed	7.462	.008	-6.196	58	.000	-8.20000	1.32344	-10.84915	-5.55085
	Equal variances not assumed			-6.196	45.448	.000	-8.20000	1.32344	-10.86482	-5.53518

Based on Table 14 the significance of F test for iteration variable is less than 5% ($0.006 < 0.05$). Therefore using 95% level of confidence the population variances of iteration variable from both groups cannot be assumed as equal. Under this assumption, the significance of T-test is less than 5% ($0.000 < 0.05$). Therefore using 95% level of confidence it can be concluded that the null hypothesis is rejected such that, there is difference in the number of iteration needed to eliminate confrontation dilemmas between group 1 and group 2. From this test, it can be estimated that group 1 (in which all agents have positive emotional state toward each other) can eliminate the confrontation dilemmas faster than group 2 (in which all agents have negative emotional state toward each other) with mean difference of $\mu_1 - \mu_2 = -24.46$ iterations.

Based Table 14 the significance of F test for trust variable is less than 5% ($0.008 < 0.05$). Therefore using 95% level of confidence the population variances of trust variable from both groups cannot be assumed as equal. Under this assumption, the significance of T-test is less than 5% ($0.000 < 0.05$). Therefore using 95% level of confidence it can be concluded that the null hypothesis is rejected such that, there is difference in the number of trust dilemma between group 1 and group 2. From this test, it can be estimated that group 1 (in which all agents have positive emotional state toward each other) have less trust dilemma than group 2 (in which all agents have negative emotional state toward each other) with mean difference of $\mu_1 - \mu_2 = -8.2$ dilemmas.

Through the sensitivity analysis in this section it has been demonstrated that in Scenario 1 the behavior exhibited by the proposed model is truly affected by the variation of agent's emotion inputs.

Sensitivity analysis Scenario 2

By using a common reference frame before 2009 as the initial position, the data obtained from 30 simulation runs are tabulated in Table 15.

Table 15 Simulation outputs from both test groups in Scenario 2

No	Goup 1		Group 2	
	iteration	trust	iteration	trust
1	28	40	37	50
2	35	53	62	49
3	17	43	27	45
4	62	37	78	46
5	26	37	34	43
6	29	30	44	55
7	16	36	86	49
8	26	47	54	43
9	22	33	84	49
10	21	34	47	51
11	29	31	77	50
12	33	36	61	43
13	53	36	58	45
14	35	45	49	43
15	22	37	56	46

No	Goup 1		Group 2	
	iteration	trust	iteration	trust
16	41	42	45	47
17	16	45	42	51
18	37	42	48	44
19	28	38	36	44
20	30	41	69	42
21	41	39	30	45
22	32	46	84	44
23	27	37	46	48
24	39	39	63	51
25	35	56	56	42
26	29	34	39	53
27	28	32	70	47
28	18	42	43	43
29	48	31	48	42
30	43	46	88	46

In Scenario 2 the result of test of normality for group 1 is described in Table 16.

Table 16 the test result for normality of group 1 outputs in Scenario 2
Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Iteration	.126	30	.200	.944	30	.119
Trust	.121	30	.200	.952	30	.196

Based Table 16 the Shapiro-Wilk test significance of iterations and trust variables are greater than 5% ($0.119 > 0.05$ and $0.196 > 0.05$). Thus, by using 95% level of confidence it can be concluded that the null hypothesis is accepted *i.e.* both the number of iterations required to eliminate confrontation dilemmas and the number of trust dilemma in group 1 of Scenario 2 are normally distributed.

The result of test of normality for group 2 from Scenario 2 is described in Table 17.

Table 17 the test result for normality of group 2 outputs in Scenario 2
Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Iteration	.142	30	.128	.948	30	.146
Trust	.133	30	.186	.931	30	.054

Based on table 17 the Shapiro-Wilk test significance of iterations and trust variables are greater than 5% ($0.146 > 0.05$ and $0.054 > 0.05$). Thus, by using 95% level confidence it can be concluded that the null hypothesis is accepted *i.e.* both the number of iterations required to eliminate confrontation dilemmas and the number of trust dilemma in group 2 of Scenario 2 are normally distributed.

After the normality of the outputs from both groups were tested, independent sample T test is performed to examine whether there are significant differences between these two groups. The null hypotheses for the independent sample T test are:

$$H_{01}: \mu_{iteration1} = \mu_{iteration2}$$

$$H_{02}: \mu_{trust1} = \mu_{trust2}$$

The results of independent sample T-test in Scenario 2 is described in Table 18.

Table 18 The independent sample T test result of Scenario 2

Independent Samples Test										
		Equality of Variances		t-test for Equality of Means						
									Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
iteration	Equal variances assumed	8.306	.006	-6.330	58	.000	-23.83333	3.76500	-31.36980	-16.29687
	Equal variances not assumed			-6.330	48.315	.000	-23.83333	3.76500	-31.40209	-16.26457
trust	Equal variances assumed	6.618	.013	-5.326	58	.000	-7.03333	1.32047	-9.67654	-4.39013
	Equal variances not assumed			-5.326	45.920	.000	-7.03333	1.32047	-9.69142	-4.37524

Based on Table 18 the significance of F test for iteration variable is less than 5% ($0.006 < 0.05$). Therefore using 95% level of confidence the population variances of iteration variable from both groups cannot be assumed as equal. Under this assumption, the significance of T test is less than 5% ($0.000 < 0.05$). Therefore using 95% level of confidence it can be concluded that the null hypothesis is rejected such that, there is difference in the number of iteration needed to eliminate confrontation dilemmas between group 1 and group 2. From this test, it can be estimated that group 1 (in which all agents have positive emotional state toward each other) can eliminate the confrontation dilemmas faster than group 2 (in which all agents have negative emotional state toward each other) with mean difference of $\mu_1 - \mu_2 = -23.833$ iterations.

Based on Table 18 the significance of F test for trust variable is less than 5% ($0.013 < 0.05$). Therefore using 95% level of confidence the population variances of trust variable from both groups cannot be assumed as equal. Under this

assumption, the significance of T-test is less than 5% ($0.000 < 0.05$). Therefore using 95% level of confidence it can be concluded that the null hypothesis is rejected such that, there is difference in the number of trust dilemma between group 1 and group 2. From this test, it can be estimated that group 1 (in which all agents have positive emotional state toward each other) have less trust dilemma than group 2 (in which all agents have negative emotional state toward each other) with mean difference of $\mu_1 - \mu_2 = -7.033$ dilemmas.

Through the sensitivity analysis in this section it has been demonstrated that in Scenario 2 the behavior exhibited by the proposed model is truly affected by the variation of agent's emotion inputs.

By comparing the results obtained in Scenario 1 and Scenario 2, it can be concluded that the proposed model robust to the variations of the initial common reference frame. This means that although the proposed model is supplied with different initial common reference frame the behavior shown by the proposed model will remain consistent. In both scenarios, the proposed model suggests that positive emotions can help eliminate the Confrontation dilemmas faster. In addition, the number of trust dilemma that may arise after the confrontation dilemmas are eliminated is fewer if all agents use positive emotions.

Experiment 2: Testing the Feasibility of Proposed Model to Describe the Dynamics of Agent's Emotion

The purpose of the experiments in this section is to test the feasibility of the proposed model in describing the dynamics of agent's emotion. The experiments in this section are divided in two scenarios. In the first scenario the common reference frames is initiated according to the common reference frame before 2008 and in the second scenario the common reference frame is initiated according to the common reference frame before 2009.

In all experiment, agent's payoffs and emotional dimensions are initiated randomly. In each experiment the trends of emotional dynamics are observed. Trends of emotional dynamics are characterized by the average of agent i 's pleasure, arousal and dominance toward all other agents. The trend is then compared to the trend of agent's emotion in the real world that has been explained in the case study. Using indicators described in the case study, the prediction of the proposed model can be considered as valid if there is at last one of the simulation result that has an interval in which agent's emotion trends are similar to the agent's emotion trends in the real world.

Testing model's validity in describing emotion trends in Scenario 1

It has been described in the case study that in the period before 2008 and after 2008 there are changes in agent's emotion with trends that are described in Table 19.

Table 19 Agent's emotion trends in Scenario 1

	Pleasure	Arousal	Dominance
Community	Decrease	Increase	Decrease
Government	Increase	decrease	Decrease
Public Enterprise	Increase	Increase	Increase

Although the behaviors that are demonstrated by the proposed model vary from one experiment to another experiment, there are some simulation results that can mimic criteria in Table 19. Example of simulation result that fulfills the above criteria is illustrated in Figure 30. In Figure 30, the interval between 7th iteration and 12th iteration has emotional trends that are similar to the criteria in Table 19.

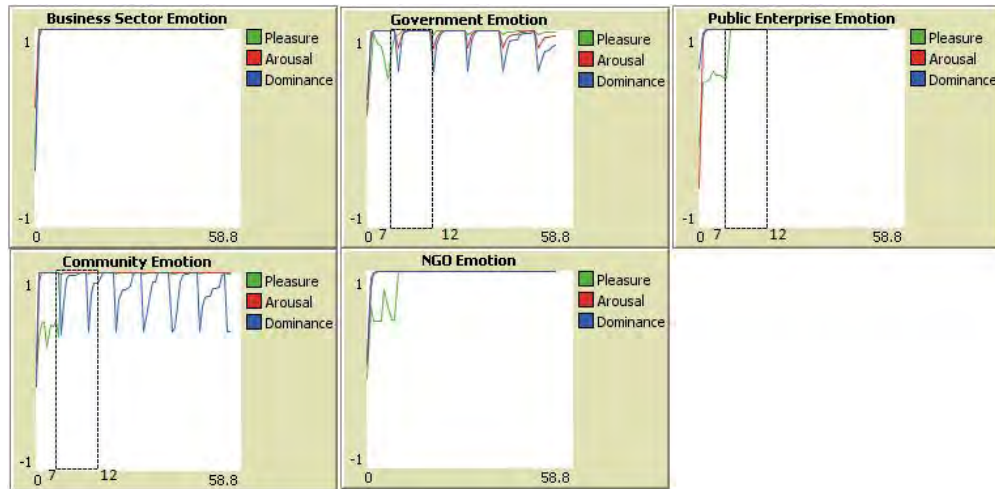


Figure 30 Agent's emotion trends output in Scenario 1

By considering the obtained simulation results, it can be concluded that in the Scenario 1 the model can produce prediction type 2 with level 1 validity.

Testing model's validity in describing emotion trends in Scenario 2

It has been described in the case study that in the period before 2009 to after 2009 there are changes in agent's emotion with trends that are described in Table 20.

Table 20 Agent's emotion trends in Scenario 2

	Pleasure	Arousal	Dominance
Business Sector	Decrease	decrease	Increase
Community	Decrease	Increase	Decrease
Government	Increase	Increase	Increase
NGO	Increase	Increase	Increase
Public Enterprise	Increase	Increase	Increase

Although the behaviors that are demonstrated by the proposed model vary from one experiment to another experiment, there are some simulation results that can mimic criteria in Table 20. Example of simulation result that fulfills the above criteria is illustrated in Figure 31. In Figure 31, the interval between 8th iteration and 10th iteration has emotional trends that are almost similar with the criteria in Table 20.

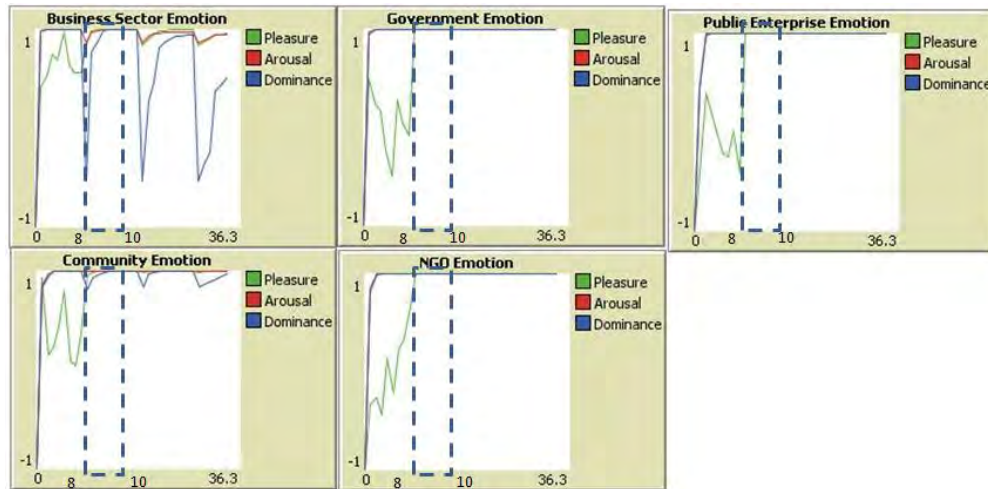


Figure 31 Agent's emotion trends output in Scenario 2

By considering the obtained simulation results, it can be concluded that in the Scenario 2 the model can produce prediction type 2 with level 1 validity.

By considering the simulation results from both scenarios, it can be concluded that although agent's emotional dimensions and a payoff are initiated arbitrarily the proposed model can produce prediction type 2 with level 1 validity. The proposed model can generate output that mimics the trend of agent's emotion in the real world either when agent's positions are initiated based on the common reference frames before 2008 as well as when the agent's positions are initiated based on the common reference frame before 2009. The model's validity applies generally for both scenario and therefore the model is feasible to help the decision makers in the real world to anticipate the dynamics of emotion during the conflict.

Experiment 3: Testing the Feasibility of Proposed Model to Describe the Dynamics of Agent's Positions

This section discusses experiments that are carried out to test whether the proposed model is feasible in describing the dynamics of agent's positions as a result of the negotiation process. The experiments in this section are divided in two scenarios. In the first scenario the common reference frames is initiated according to the common reference frame before 2008 and in the second scenario the common reference frame is initiated according to the common reference frame before 2009. In each experiment, agent's payoffs and emotional dimensions are initiated randomly.

Because there are some parts of the proposed model that have random nature, the probability of occurrence of configuration that is exactly similar to the common reference frame in the real world is very small. Therefore the in this study the proposed model is considered as valid in describing the dynamics of agent's positions if it can mimic the majority of agent's position for a certain option. The common reference frames after 2008 and after 2009 are set as the target condition that should be mimicked by the proposed model.

Testing model's validity in describing majority positions in Scenario 1

Based on the case study the majority of agent's positions for each option after 2008 are described in Table 21.

Table 21 the majority of positions after 2008

PARTICIPANT OPTION	Majority Position
Stop damaging drainage	Yes
Stop polluting Citarum	Yes
Protest	No
Stop illegal logging	No
Stop waste disposal to river	Yes
Maintenance down stream river	Yes
Give sanction to people	Yes
Give sanction to business sector	Yes
Give real estate license	No
Give more authorities to public enterprise	Yes
Protest	No
Proactive for agency sustainability	Yes

Although the behaviors that are demonstrated by the proposed model vary from one experiment to another experiment, there are some simulation results that can mimic criteria in Table 21. Example of simulation result that mimics the above criteria is illustrated in Figure 32.













PARTICIPANT OPTION	Net Logo Pond	Appropriate
Stop damaging drainage		Appropriate
Stop polluting Citarum		Appropriate
Protest		Appropriate
Stop illegal logging		Appropriate
Stop waste disposal to river		Appropriate
Maintenance down stream river		Appropriate
Give sanction to people		Appropriate
Give sanction to business sector		Appropriate
Give real estate license		Not Appropriate
Give more authorities to public enterprise		Appropriate
Protest		Appropriate
Proactive for agency sustainability		Appropriate

Figure 32 Majority of agents position in Scenario 1 based on simulation output

In Figure 32, the first column shows the options owned by each agent, the second column shows the preview of the simulation result in NetLogo simulation and the third column shows the validity of the proposed model in describing the majority of agent's positions for each option. In the third column, appropriate label is given if the majority of agent's position predicted by the proposed model is similar to the majority of agent's position in the real world. Figure 32 shows that from twelve options in the common reference after 2008, the proposed model can predict the majority of agent's position of eleven options appropriately. By considering the obtained simulation results, it can be concluded that in the Scenario 1 the model can produce prediction type 2 with level 1 validity.

Testing model's validity in describing majority positions in Scenario 2

Based on the case study the majority of agent's positions for each option after 2009 are described in Table 22.

Table 22 the majority of positions after 2009

PARTICIPANT OPTION	Majority Position
Stop damaging drainage	Yes
Stop polluting Citarum	Yes
Protest	No
Stop illegal logging	Yes
Stop waste disposal to river	Yes
Maintenance down stream river	Yes
Give sanction to people	Yes
Give sanction to business sector	Yes
Give real estate license	No
Protest	Yes
Regulate the waste disposal	Yes
Reforestration	Yes

Although the behaviors that are demonstrated by the proposed model vary from one experiment to another experiment, there are some simulation results that can mimic criteria in Table 22. Example of simulation result that fulfills the above criteria is illustrated in Figure 33.













PARTICIPANT OPTION	NetLogo Pond	Appropriate
Stop damaging drainage		Appropriate
Stop polluting Citarum		Appropriate
Protest		Not Appr
Stop illegal logging		Appropriate
Stop waste disposal to river		Appropriate
Maintenance down stream river		Appropriate
Give sanction to people		Appropriate
Give sanction to business sector		Not Appr
Give real estate license		Appropriate
Protest		Appropriate
Regulate the waste disposal		Appropriate
Reforestration		Appropriate

Figure 33 Majority of agents position in Scenario 2 based on simulation output

In Figure 33, the first column shows the options owned by each agent, the second column shows the preview of the simulation result in NetLogo simulation and the third column shows the validity of the proposed model in describing the majority of agent's positions for each option. In the third column, appropriate label is given if the majority of agent's position predicted by the proposed model is similar to the majority of agent's position in the real world. Figure 33 shows that from twelve options in the common reference after 2009, the proposed model can predict the majority of agent's position of ten options appropriately. By considering the obtained simulation results, it can be concluded that in the Scenario 2 the model can produce prediction type 2 with level 1 validity.

Although the model's accuracy in predicting agent's majority positions that will emerge is not perfect however, the proposed model is quite valid in describing dynamics of changes in agent's position that may occur during the conflict. In the first scenario the proposed model the model can describe a changing in the majority of agent's position regarding the give sanction to people option. Before 2008 the majority of agents reject this option but, after 2008 the majority of agents accept this option. In addition, the model can describe a changing in the majority of agent's position regarding the proactive for agency sustainability option. Before 2008 the majority of agents are indifferent towards this option, but, after 2008 the majority of agents accept this option. In the second scenario, the model can describe a changing in the majority of agent's position regarding the protest the options owned by the NGO. Before 2009, the majority of the agents reject this option but, after 2009 the majority of the agents accept this option.

By considering the simulation results from both scenarios, it can be concluded that although agent's emotional dimensions and a payoff are initiated arbitrarily

the proposed model can produce prediction type 2 with level 1 validity. The model's validity applies generally for both scenario and therefore the model is feasible to help the decision makers in the real world to anticipate the changes in agent's position that may occur during the conflict.

Experiment 4: Inferring Suggestions for Real World Agents

After the sensitivity and feasibility of the proposed model are tested, suggestions that can be proposed to the real world agents, not just to resolve the conflict but also to obtain the final results that can improve the condition of the Citarum River, are explored in this section. Suggestions that will be proposed are taken form of emotional strategy that should be used by the agents during the negotiation with other agents. These suggestions are expected to be valid for the period of 2009 onwards.

It can be judged intuitively that the condition of the Citarum River would improve if all agents agree that:

1. Business sectors are no longer damage the city drainage and no longer dispose of waste into the river Citarum.
2. Community stops illegal logging activity and no longer throws household waste into the Citarum River.
3. Government maintain downstream river and no longer permit real estate construction.
4. Public enterprises help to regulate waste disposal and to do Reforestation.

To identify strategies that can achieve the above criterias, agent's positions in the simulation are initiated by using common reference frame after 2009. Agent's payoff and emotions are initiated randomly. The simulation is then run repeatedly. In each simulation the final common reference frame that is obtained and the emotion that produce it are observed.

Figure 34 shows some examples of simulations that meet the above criterias.

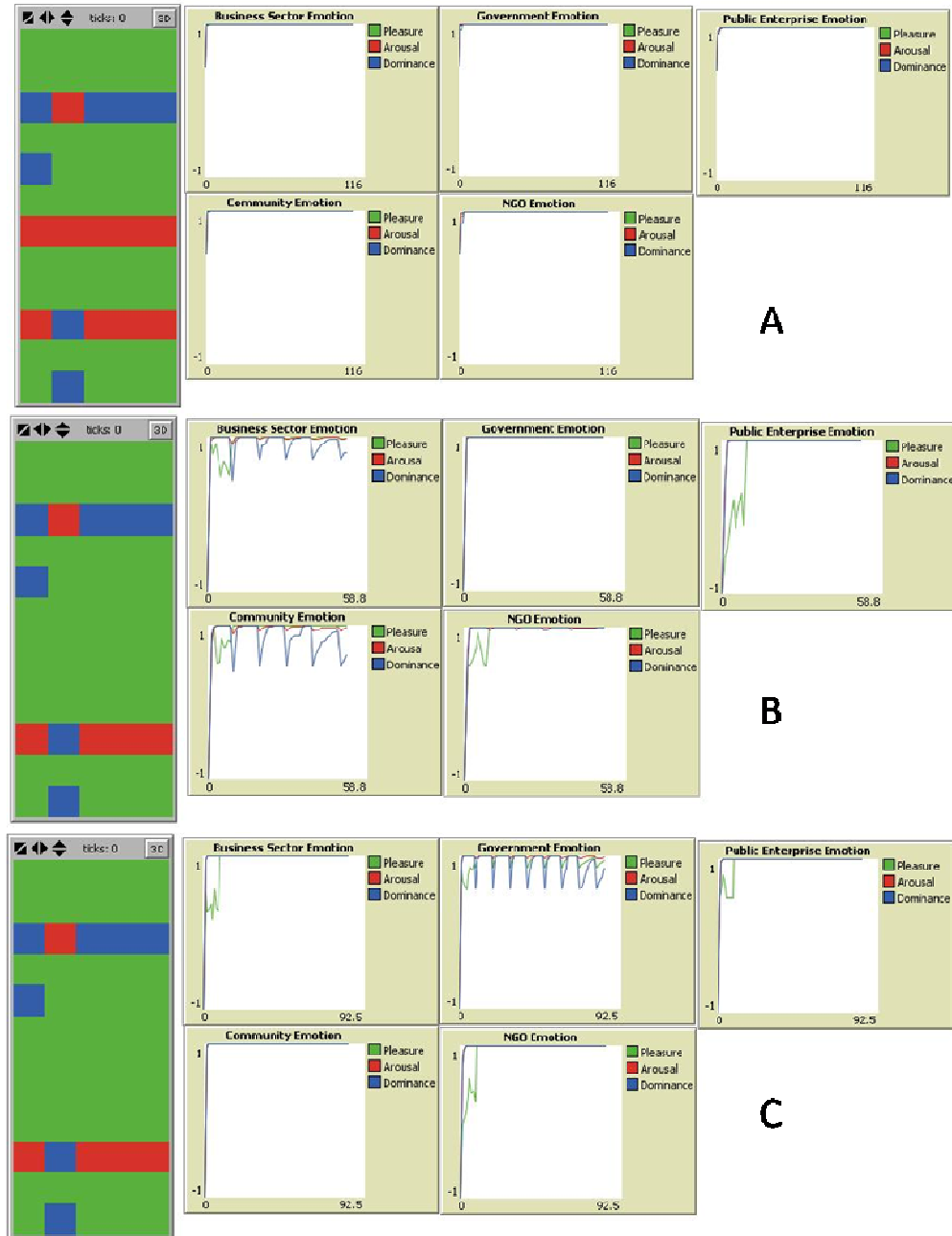


Figure 34 The simulation result that produce desired resolution in Citarum River Basin conflict

From the simulation runs it is observed that the above criterias will be achieved only when the trend of agent's emotion are increase. Although during the negotiations process agent's emotions can fluctuate, but as long as these fluctuations do not causes agent's to have negative emotional state, then the desired condition is still possible to be achieved. This is shown in Figure 34.B and

34.C. However, the desired condition conditions do not always occur even when the average of agent's emotion are positive and increasing in general. Figure 35 describes this event.

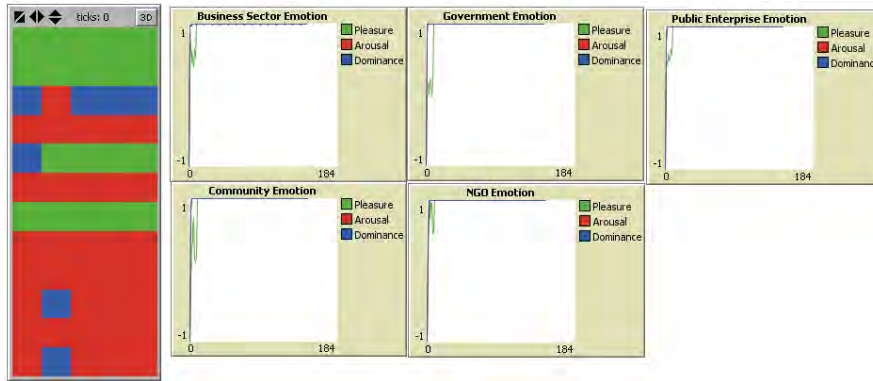


Figure 35 Simulation result that produce undesired resolution when agent's emotions are positive

The desired resolution also does not occur when the averages of agent's emotions toward other agents are negative or the trend is decrease. Figure 36 shows the simulation results that illustrate this situation.

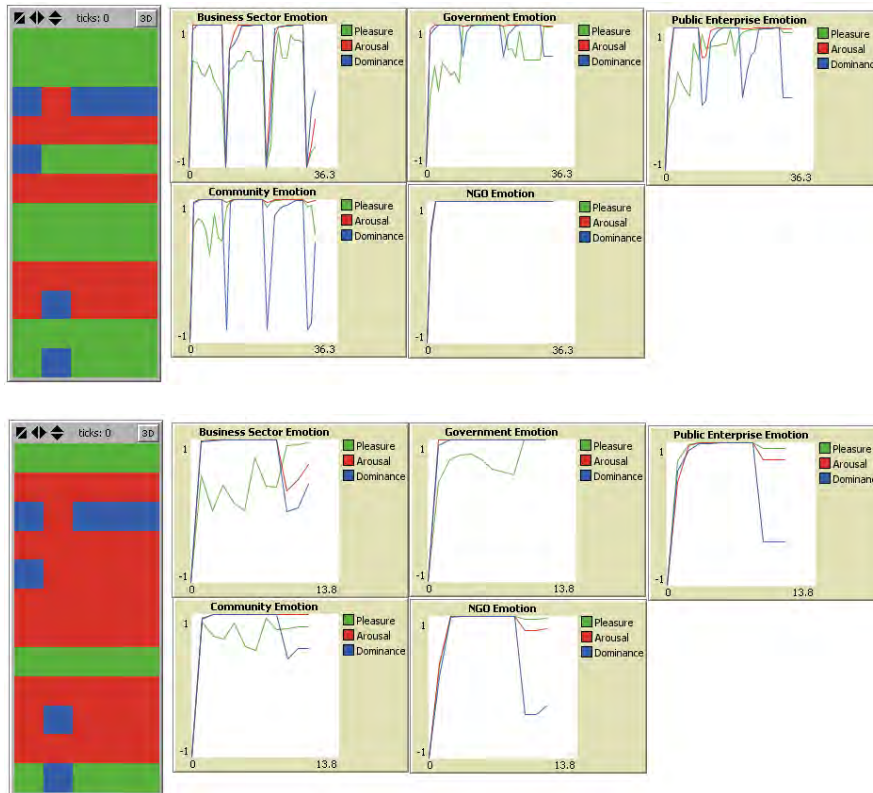


Figure 36 Simulation result that produce undesired resolution

CONCLUSIONS AND FURTHER RESEARCH

Conclusions

In this research an agent-based simulation model of dynamics of confrontation that involves emotion and learning has been constructed. In this model agents are negotiate based on the drama theory concept and have emotion that is modeled using the PAD model.

In this model, agents negotiate in order to attract other agents to adopt its positions. The negotiation process occurs iteratively in accordance with the nature of negotiation in the real world. Negotiation protocol in this model is constructed based on the concept of rational negotiation. In this negotiation protocol, agents can recognize the position declared by other agents but can only estimate the payoff that will be obtained by other agents from their declared position. This is in line with the realities of negotiation in the real world. In the constructed negotiation protocol, emotions play a role in magnifying or diminishing the perception of other agents on the offer given by an agent. This is consistent with the role of emotions in negotiations in the real world. During the negotiation process agent's emotion can change based on the result of its interaction with other agents. The dynamics of agent's emotion is based on the flow model of emotion concept. By adopting this concept agent's emotion dynamics that occur in the negotiations in the real world can be facilitated. Since the assumptions used in this model are very close to the real world negotiation process, the proposed model can be considered valid as conceptually.

In the proposed model, the negotiation process occurs as long as there are confrontations dilemmas exist among agents. There are two types of confrontation dilemmas in the proposed model *i.e.* persuasion and rejection dilemma. If the confrontation dilemmas among the agents have been successfully eliminated, there are still possibilities of the emergence of trust dilemma among agents. The number of iterations required to eliminate confrontation dilemmas and the amount of trust dilemma that appears become the main parameters to test the sensitivity of the model. The first experiment shows that the number of iterations required to eliminate the confrontation dilemmas and the number of trust dilemma that arise are significantly lower if all agents have positive emotions towards other agents. This experiment also indicated that the results of the analysis are robust to the initial common reference frame. This means that although the model is calibrated for other conflict situation the analysis results will remain consistent.

In the second experiment the model feasibility to describe the trend of agent's emotion that can arise in the real world is tested. By comparing the trend of agent's emotion generated by the simulation and the trend of agent's emotion obtained through focus group discussion, it can be concluded that there are results of simulations that can mimic the trend of agent's emotion in the real

world. Therefore, it can be concluded that the model can produce prediction type 2 with level 1 validity. The validity of the proposed model to describe the trend of agent's emotion is robust against initial common reference frame. This means that the model will also valid to describe the trend of agent's emotion that may appear in other conflict situation. Since the validity of the proposed model applied generally, it is feasible to help agents in the real world to anticipate trend of agent's emotion that may appear during the confrontation. Ofcourse, to give higher level of prediction and validity, more accurate measurements of inputs parameters are required.

In the third experiment the feasibility model to describe the majority of agent's positions that can arise in the real world is tested. By comparing the common reference frames generated by the proposed model with the common reference frames obtained through focus group discussion it can be concluded that there are results of the simulation which can resemble the majority of agent's positions the real world (although the results are not 100% accurate). So, it can be concluded that the model can produce prediction type 2 with level 1 validity. The validity of the proposed model to describe the majority of agent's positions is robust against initial common reference frame. This means that the model will also valid to describe the majority of agent's position that may appear in other conflict situation. Since the validity of the proposed model applied generally, it is feasible to help agents in the real world to anticipate the final majority of agents' positions that may occur as the result of the confrontation. Ofcourse, to give higher level of prediction and validity, more accurate measurements of inputs parameters are required.

After testing the model's feasibility the recommendations for agents in the Citarum river basin conflict are explored in the fourth experiment. The result of this experiment shows that in order to achieve resolution that can help to improve the condition of the Citarum River, it is suggested to the agents in the real world to use positive emotions in negotiation with other agents. In addition, the use of positive emotions accelerates the achievement of conflict resolution, and reduces the possibility of the emergence of trust dilemma, as discussed in the first experiment.

Further Research

The proposed model in this study still has some weaknesses. In the proposed model it is assumed, that an agent is a coalition of a number of actors in the real world. Members of each coalition are considered fixed and not changed during the course of the conflict. Through the qualitative study conducted in this study, it is identified that the members within each coalition can change with during the course of the conflict. To develop this model further it is important to consider the process regarding the formation mechanism and the dynamics of agent's coalition.

In the drama theory model there are six drama dilemmas that can arise in a conflict. This model only accommodates three dilemmas among those six dilemmas. This model can be developed further by also model the positioning, threat and cooperation dilemma.

In experiments conducted with the proposed model a number of inputs such as agent's payoff and the agent's emotion are initialized randomly. In order to utilize this model further to assist agents in the real world in anticipating the dynamics of conflict that may occur, instruments that can help to identify the value of these variables need to be constructed.

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Appendix A Proceedings of International Industrial Engineering and Service Science Conference 2011

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Promoting Collaboration among Stakeholders in Citarum River Basin Problem

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ABSTRACT

This research aims to develop an agent-based simulation model of the dynamic of negotiation based on interaction among autonomous agents, who have different interests and act based on their emotion. Agents in this model are equipped with emotion and ability to learn, and negotiate each other based on drama theory framework. To illustrate the simulation model, environmental conflict case in Citarum river basin is discussed in this paper. Qualitative study is used to gather information regarding the agent's historical options, positions and preferences. Based on the qualitative study result, the historical dynamics of common reference frame in the real world is obtained. The simulation model is then tested and validated against historical dynamics of the real conflict in Citarum river Basin. Using this simulation it is possible to describe possible outcomes of the conflict evolution and suggest policy in order to reduce dilemmas and encourage collaboration among agents in the real world.

Keywords: agent based simulation, drama theory, dilemma, collaboration

1. Introduction

A conflict, from mere difference of opinion to deadly confrontations, is unavoidable in daily life. Negotiation as an effort to resolve conflict is a very common process in everyday life. This is why negotiation process is studied in many scientific fields such as economy, political science, psychology, organizational behavior, decision sciences, operations research and mathematics [1].

One case is the conflict that occurred in the Citarum River Basin. Citarum River is the longest river in West Java province. Many people depend on the Citarum River, making it one of the most strategic river in Indonesia. Unfortunately, the condition Citarum River now has changed completely. Since the industrialization in the 80s the Citarum River turned into industrial landfills. At present there are around 500 textile factories that dispose their waste into Citarum River, many of which are conducted without proper waste treatment. Citarum River condition is worsened by the population explosion in the upstream area. Increasing population has also increased the number of illegal logging and disposal of household waste. As a result, flood always occurs during the rainy season due to sedimentation in downstream areas of rivers and increasing number of barren land. Citarum River Basin problem involves many stakeholders through the literature study and focus group discussion; there are at least 33 stakeholders in Citarum River Basin Conflict. These stakeholders have conflicting interest. Because of this, efforts to restore the condition of Citarum River become useless.

Negotiation in the real world such as the one in Citarum River Basin conflict possesses several characteristics *i.e.*: 1) *decentralized* [1], means that parties in a negotiation can have different frames and strategy in seeking resolution of conflict; 2) involve communication among parties [1]; 3) decisions of negotiators are interlinked through communication processes that involve many different levels [2]; 4) Involve incomplete information [1], for example, a party cannot know for certain utilities from the other parties; 5) involves repeated interaction with no well-structured sequences [1]; 6) In a negotiation, emotion is an important device in structuring goals, values and preferences [3] and affects communication [2] in a negotiation.

Characteristics owned by a negotiation process reflect the characteristics of a complex system since: 1) the elements involved in a negotiation process are heterogeneous and autonomous agents (parties); 2) agents involved a negotiation process are bounded rational, they can have bias in information and may have a misperception toward the other

agents; 3) communication process in a negotiation involves transmission of knowledge that will influence the behavior of its recipient; 4) negotiation is an iterative process. Such process involves feed-back loops that allows enable an agent to learn and revise his/her strategy. This makes the system (condition during the negotiation process in this case) evolve over time [4]; 5) in general, interactions in a negotiation process are non-linear in the sense of, for an action there are many possible outcomes that could be produced and, for an outcome there are many possible actions that may cause it.

This study aims to construct an agent-based simulation of the dynamics of negotiation based on drama theory frame-work. Agents in the constructed simulation are equipped with emotions and ability to learn. The agent-based simulation is chosen because it can minimize the number of simplifications used by its ability to fully represents individuals and model bounded rational behavior while, drama theory is chosen because, it proposes an episodic model whereby situations unfold. Using the constructed model, this study will propose strategy that can promote collaboration among stake holders in Citarum River Basin Conflict.

2. Proposed Mechanism

2.1. Model of Agent's Options, Position and Threat

In drama theory, there are a number of agents who have options, positions, preferences and threats. Interaction among agents occurred under the common reference frame that is, the joint perception regarding the conflict that occurs. In this simulation, an agent is represented as a column in a common reference frame. Each agent i , has a number of options (O_{ki}) that are represented as rows in common reference frame. At each iteration t , agent i has position to *accept* or to *reject* each its own option. Agent i 's position toward its own options will generate payoff (Vo_{ki}^t) for the agent i . Agent i 's payoff has two dimensions namely *accept dimension* and *reject dimension*. If agent i 's position is to accept option O_{ik} , then agent i 's payoff in *accept dimension* is assigned as x (a real number between 51 to 100) and, agent i 's payoff in the *reject dimension* is assigned as $(100 - x)$. The opposite rule applies if agent i position is to reject option O_{ik} .

Each agent j ($j \neq i$), has position to *accept*, to *reject* or *indifferent* toward option O_{ik} of agent i . Agent j 's position toward agent i 's options will generate payoff (Vpo_{kij}^t) for agent j . Agent j 's payoff has two dimensions namely *accept dimension* and *reject dimension*. If agent j 's position is to accept option O_{ik} , then agent j 's payoff in *accept dimension* is assigned as x (a real number between 51 and 100) and, agent j 's payoff in *reject dimension* is assigned as $(100 - x)$. The opposite rule applies if agent j position is to reject option O_{ik} of agent i . If agent j 's position is *indifferent* toward option O_{ik} of agent i then agent j 's payoff in both dimensions are assigned as 50.

The total real payoff obtained by each agent by adopting its own positions in each iteration t is calculated as follows:

$$Vp_i^t(p_i^t) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad \begin{array}{l} m = \text{number option and } (i \neq j) \\ p_i^t = \text{positions of agent } i \text{ in iteration } t \end{array} \quad (1)$$

While, the total payoff obtained by agent i by adopting agent j 's positions in each iteration t is calculated as follows:

$$Vpp_i^t(p_j^t) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad \begin{array}{l} m = \text{number option and } (i \neq j) \\ p_j^t = \text{positions of agent } j \text{ in iteration } t \end{array} \quad (2)$$

Both payoffs are stored in *real payoff matrix*. The columns of this matrix represents agent i and the rows of this matrix represents agent j . The elements on the diagonal of the *real payoff matrix* represent the payoff that will be obtained by each agent by adopting its own position.

For all options, a set of threats is defined. The total payoff obtained by agent i by adopting threatened future in each iteration t is calculated as follows:

$$Vpt_i^t(T) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad \begin{array}{l} m = \text{number option and } (i \neq j) \\ T = \text{threat} \end{array} \quad (3)$$

Each agent i have an estimation regarding the payoff that will be obtained by other agents for each of their position. Agent i 's estimation toward agent j 's payoff is also consists of two dimensions, *i.e.* *accept dimension* and *reject dimension*. If agent j 's accepting option O_{ik} , then agent i will estimate that agent j will obtained payoff equal to x (x is a random number from 51 to 100) in *accept dimension* and $100 - x$ in *reject dimension*. The opposite rule applies if agent j is rejecting option O_{ik} . If agent j is indifferent toward option O_{ik} then, agent i will estimates that agent j 's payoff in both dimensions are equal to 50. All agents stored their estimation regarding other agent's payoffs in *estimated accepting payoff matrix* and *estimated rejecting payoff matrix*. The columns of agent i 's *estimated payoff matrices* represent agent j and the rows represent option O_{ik} .

2.2. Modeling Agent's Dilemmas

In each iteration, if agent i and agent j has incompatible position (*e.g.* agent i accept option O_{ik} while agent j reject the option) among them, confrontation dilemmas will emerge. Agent i 's dilemmas toward agent j are determined based on the payoff that will be obtained by agent i . There are two kinds of dilemmas that are considered in this research, *i.e.* rejection dilemma and persuasion dilemma [5]. Those dilemmas are defined as follow:

- If agent i 's payoff by adopting agent j 's position is greater than or equal to agent i 's payoff to adopt its own threat then, agent i has rejection dilemma toward agent j .
- If agent i 's payoff by adopting agent j 's position is less than or equal to agent i 's payoff to adopt its own threat then, agent j has persuasion dilemma toward agent i .

If there are no incompatible positions among agents, the collaboration dilemmas still may occur. The collaboration dilemma considered in this research is the trust dilemma. Agent i who has compatible position with agent j , will has trust dilemma toward agent j , if agent i 's estimation regarding agent j 's payoff is not in accordance with agent j 's position. For example, agent i will have trust dilemma toward agent j if both agent i and j accept option O_{ik} but agent i estimates that agent j will has greater payoff by rejecting option O_{ik} .

2.3. Negotiation Protocols

In this negotiation protocol, each agent is equipped with emotion that is modeled using PAD temperament model [6]. In this model, emotional state is constructed by three independent dimensions *i.e.* pleasure arousal and dominance. The formulation of agent's emotional state is as follows [7].

$$Se_{ij}(r_p, r_a, r_d) = r_p \cdot (1 + r_a) - r_d \quad (4)$$

During the simulation agents will conduct negotiation for options with incompatible positions (*e.g.* agent i accept the option while agent j reject the option). The negotiation protocol in this research is constructed based on rational negotiation framework in which, agent i will offer certain amount of its payoff (st_i) in order to shift agent j 's position toward agent i 's position. The potency of agent i 's offer to shift agent j 's position (Ov_{ij}) is affected by agent i 's emotional state toward agent j (Se_{ij}), and agent j 's perception toward agent i 's offer (Ov_{ji}) is affected by agent j 's emotion toward agent i (Se_{ji}).

$$Ov_{ij} = Se_{ij} \times st_i + st_i \quad (5)$$

$$Ov_{ji} = Se_{ji} \times Ov_{ij} + Ov_{ij} \quad (6)$$

Suppose agent i 's position is to accept option k and agent j 's position is to reject option O_{ik} , then agent i 's payoff in *accept dimension* will then subtracted by Ov_{ij} and agent i 's payoff in *reject dimension* added by Ov_{ij} while, agent i 's estimation toward agent j 's payoff in *reject dimension* is also subtracted by Ov_{ij} and agent i 's estimation toward agent j 's payoff in *accept dimension* is added by Ov_{ij} . In the other hand, agent j 's payoff in *accept dimension* is added by Ov_{ji} and agent j 's payoff in *reject dimension* is subtracted by Ov_{ji} while, agent j 's estimation toward agent i 's payoff in *reject dimension* is added by Ov_{ij} and agent j 's estimation toward agent i 's payoff in *accept dimension* is subtracted by Ov_{ij} . Similar rules apply for the opposite condition.

Promoting Collaboration among Stakeholders in Citarum River Basin Problem

Each time an offer from agent i is perceived by agent j agent i will compare the response of agent j with agent j 's response in the previous iteration. Then, agent i 's emotion state toward agent j will change according to the concept of Flow Model of Emotion [8] which then mapped into PAD dimensions.

Table 1. Change in agent i 's emotional states

Agent i offer (compare to previous iteration)	Agent j perception (compare to previous iteration)	Change in agent i emotion state toward agent j		
		r_p	r_a	r_d
Higher	higher	+	+	+
Higher	lower	-	+	+
Lower	higher	+	+	-
Lower	lower	-	-	-

Through the negotiation process agents will learn to identify the emotional state that can produce the biggest shift in position of other agents (best emotional state). Learning mechanism which is built in this study is based upon the assumption that each agent will revise his/her emotional state according to his/her experiences in the previous iterations. Each time agent i give an offer to agent j , agent i will record emotional state that he/she use and the shift resulted in agent j 's position. If in the current iteration the shift in agent j 's position is higher or equal to the shift in agent j 's position in the previous iteration then, agent i will revise his/her best emotional state according to his/her emotional state in the current iteration [9].

3. Case Study: Citarum River Basin Conflict

The simulation model in this study was constructed by using NetLogo version 4.1.2. In this study the common reference frame of the Citarum River Basin conflict is used as the simulation input. This Common reference frame was identified through observation and focus group discussion with the stake holders in Citarum River Basin conflict. Through this qualitative study five agents was identified *i.e.* Government (G), Public Enterprise (PE), Green (GR), Community Alliance (CA), Enterprise (E). Agent's options, positions, and threat are described in the following table.

Table 2. Common reference frame in Citarum River Basin Conflict

Options	Threat	CA	E	G	GR	PE
Community Alliance						
Stop seasonal agriculture	N	Y	N	Y	Y	Y
Anarchy demonstration	Y	Y	N	N	N	N
Conducting government advices	N	N	N	Y	Y	Y
Enterprise						
Stop polluting citarum river	N	Y	N	Y	Y	Y
Stop damaging drainage	N	Y	Y	Y	Y	Y
Do CSR	N	Y	Y	Y	Y	Y
Government						
Give sanction to offender	Y	Y	N	Y	Y	Y
Coordinating among agencies	N	Y	Y/N	Y	Y	Y
Stop permitting destructive residential and industry	Y	Y	N	N	Y	Y
Implement recovery program for Citarum	N	Y	Y	Y	Y	Y
Give more authority to NGOs and Public Enterprise	N	Y/N	Y/N	N	Y	Y
Green						
Help government	N	Y	Y/N	Y	Y	Y
Protest the government policies	Y	Y	Y	N	Y	Y/N
Public Enterprise						
Pro active for agencies sustainability	N	Y	Y	Y	Y	Y

Promoting Collaboration among Stakeholders in Citarum River Basin Problem

During the simulation process three scenarios are tested. In the first scenario, agents are negotiating by using a negative emotion toward other agents. In this scenario the value of pleasure, arousal and dominance of each agent towards the other agents are set randomly from 0 to -1. In the second scenario, agents are negotiating by using a neutral emotion toward other agents. In this scenario the value of pleasure, arousal and dominance of each agent are set as zero. In the third scenario, agents are negotiating by using a positive emotion toward other agents. In this scenario the value of pleasure, arousal and dominance of each agent towards the other agents are set randomly from 0 to 1. The random assignment of the emotional dimensions is conducted because it is not possible to conduct empirical measurement to so many stake holders in the real world.

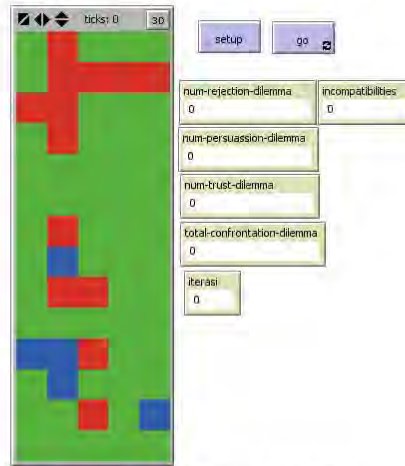


Figure 1. Simulation Interface

Each scenario is run thirty times. In every run the number of iterations needed to eliminate confrontation dilemmas and the number collaboration dilemmas that occur when the position of all agents have been compatible are observed. Assuming each run as a sample then, the simulation results can be tabulated and tested using ANOVA to observe the differences among scenarios. The comparison among scenarios is shown in Table 3.

Table 3. Comparison among scenarios

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Scenario	(J) Scenario	Mean Difference (I-J)	Std. Error	Sig.	Interval Lower Bound	Interval Upper Bound
Trust	1	2	8.30000	1.22259	.000	5.3579	11.2421
		3	10.70000	1.22259	.000	7.7579	13.6421
	2	1	-8.30000	1.22259	.000	-11.2421	-5.3579
		3	2.40000	1.22259	.131	-.5421	5.3421
	3	1	-10.70000	1.22259	.000	-13.6421	-7.7579
		2	-2.40000	1.22259	.131	-5.3421	.5421
Iteration	1	2	498.00000	58.23422	.000	357.8641	638.1359
		3	530.10000	58.23422	.000	389.9641	670.2359
	2	1	498.00000	58.23422	.000	-638.1359	-357.8641
		3	32.10000	58.23422	.846	-108.0359	172.2359
	3	1	530.10000	58.23422	.000	-670.2359	-389.9641
		2	-32.10000	58.23422	.846	-172.2359	108.0359

The comparison results shows that if agents use negative emotions to other agents during the negotiation process then, in average the time required to eliminate the confrontation dilemmas will be longer than if they use neutral or positive emotions. In addition, the numbers of collaboration dilemmas that arise when agents use negative emotions are significantly higher than if they use neutral or positive emotions.

4. Conclusions

Through this study an agent-based simulation of the dynamics of negotiation based on drama theory frame-work have been constructed. The simulation model has incorporate agent's emotions and learning ability into a negotiation protocol. This model is able to show the evolution of a common reference and show the effect of agent's emotional states toward the number of dilemmas that will be produced in the given common reference frame, the time required to eliminates confrontation dilemmas and the collaboration dilemmas that potentially arise after all agents reach compatible positions.

The proposed model is the used to analyze the conflict in Citarum River Basin. Based on the simulation results it can be concluded that if agents use negative emotions to other agents during the negotiation process then, the time required to eliminate the confrontation dilemmas will be longer than if they use neutral or positive emotions. In addition the simulation results also show that the numbers of collaboration dilemmas arise when agents use negative emotions are significantly higher than if they use neutral or positive emotions. In the real world, positive emotions can be implemented in several forms for example, willingness to compromise, give empathy to others, to convince others etc. Threatening others, imposing the will or the anarchist protest is not recommended to be done.

In the future, the model in this study is still need to be improved by integrating other dilemmas such as threat dilemma and positioning dilemma. The feasibility and accuracy of this simulation to represents the evolution real world conflict is also still need to be investigated.

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A Drama Theoretical Approach of Stakeholder Analysis of Citarum River Pollution Problem in Indonesia

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ABSTRACT

Citarum river is very important for citizen in West Java to meet their needs. They use Citarum river water for irrigation, plantation, households and even industrial needs. However, this river is also become a 'dustbin' for many people around there. Many people around there throw garbage and waste into the river in consideration of more practical and economical. In addition, the environment exploitation, such as deforestation and change forests functions into residential also contributed to worsen the Citarum river condition. As a result, the river is overflowed and there is a flood occurred very often. There are variety stakeholders who have it own interests of the river, such as community, business sector, governments, NGOs and public enterprise. Every stakeholder has the same vision to contribute and improve the river condition, but each party has a different interest that arises in a conflict very often. The purpose of this paper is to analyze the conflicts that arise there between stakeholders by using Drama Theory before and after 2009. By applying Drama Theory in stakeholder analysis and resolving the dilemmas that arise between them, we can identify and find a solution for collaboration.

Keywords: *Drama Theory, stakeholder Analysis, Dilemma, Conflict.*

1. Introduction

Citarum River is an important river for people in West Java. Almost everyone in this province use the water for supporting their life. Citarum upstream is in Wayang Mountain, located in south Bandung and the downstream is in Karawang, of the total length about 225 km [1]. Water from this river is very useful, especially for agriculture, household, industry, even become electricity power source. Water using from this river become increase, along of the rapid population growth. However unfortunately, people forget to protect the water quality. Many people in Citarum area throw garbage and waste to the river. Today, Citarum's quantity and quality are getting worse every day. People face a lot of problems from this river. One of the problems is trivialization. The highly dangerous waste from the industry is also become the serious problem for Citarum. Besides that problem, a change from forest to agriculture and housing is one of the extremely problems to cause river's trivialization and causing the flood.

There are many reactions from people for this bad condition. Basically, each agent has the same goals. They want Citarum become clean and health. However, currently, there is no agreement from each agent to restore the river. One of the reasons is every agent have their own priority. There have been an effort to restore the river, but the result is not significant. Based on the research result in 2009, conflict that appear from each agent can be eliminated if their use the positive emotion when their coordinate of another agent. However, the dilemma can still appear. According to previous result, in this paper, we identify the dynamics of conflict and dilemmas between stakeholder of Citarum river basin problem in two episodes, before and after 2009. By applying Drama Theory in stakeholder analysis and resolving the dilemmas that arise between them, we can identify and find a solution for collaboration.

2. Literature Study

Conflict is always happened in every organization, but is not always become a bad thing if it can be organized in a good way, in fact, conflict has a positive effect for its organization. There are a lot meanings of conflict, [2] said that *Conflict theorists emphasized the importance of interests over norms and values, and the ways in which the pursuit of interests generated various types of conflict as normal aspects of social life, rather than abnormal or dysfunctional occurrences.* Conflict is a contradiction process that express between two or more agents who have dependence about a conflict ob-

ject, using a behavior pattern and conflict interaction that can produce the conflict itself [3]. There are some kind and criteria about conflict:

1. Personal and Interpersonal Conflict. Personal conflict is conflicts that happen inside someone because have to choose from some alternative choices. Interpersonal conflict is conflicts that usually happens in an organization, between parties and have dependence in work to reach organizational goals.
2. Interest Conflict. Interest conflict is a conflict situation where someone has a bigger personal interest than his or her interest organization so it will affect his or her job as a social official to do implements a social system.
3. Reality and Non-reality Conflict. Realistic conflict is a conflict that can be happened because there is some difference's way to reach the goals. While nonrealistic conflict is a conflict that can be happened, but is nothing to do of substantial issues about the main conflict.
4. Destructive and Constructive Conflict. In destructive conflict, each party who has a problem is not flexible, because the goals of conflict are defined in narrow ways to beat other parties, while constructive conflict is a conflict which in the process is to find a better solution to solve the problem.

Conflict is a common thing that can be happened in every group or organization, even sometimes we cannot avoid the conflict. Conflict is not always having a negative effect, because conflict eventually gives a positive effect for its organization. Every member of the organization has to learn from every conflict and creates the mechanism to increase their organization productivity. There is some method that can be use to solve the conflict. Drama theory is one of the analyses. *Drama theory is a game theory framework that combined of the emotion parameters to solve the complexities of the conflict.* [4], [5], [6] said that in a negotiation, parties will face dilemmas that appear, and it will hinder the resolutions. There are two kinds of dilemma:

a. Confrontation Dilemma:

Dilemma will appear when all parties do not have the same position, or at least there is one party have a different position or incompatible of another party, and it will cause the party who has a dilemma not credible to apply the threat.

● *Threat dilemma*

Party 1 have a threat dilemma of party 2 if the party 1's dilemma is not credible by party 2, because party 2 know there is another possible scenario that more preferred by party 1 than threat position. Party 2 consider party 1 only bluffing to the other party. In this condition, **party 1 have to be more serious about making a credible threat of anger or hate (negative emotion).**

● *Rejection dilemma*

Party 1 have a rejection dilemma of party 2 if party 1 have a barrier to convince another party that party 1 reject a party 2's position, because party 2 doubt party 1 prefer the threat than party 2's position. In this situation, party 1 have to make the threat more credible by party 2 using negative emotion.

● *Positioning dilemma*

Party 1 have a positioning dilemma of party 2, if party 1 prefer party 2's position than its own position. But, party 1 can reject party 2's position to get another better offer, or because unrealistic party 2's position, or maybe party 1 prefer threat position than party 2's position, or maybe party 1 do not believe of party 2.

● *Persuasion dilemma*

Party 1 have a persuasion dilemma of party 2 if party 1 prefer a party 2's position than threat position, so party 1 have barriers to convince party 2 to accept its position.

b. Collaboration/Cooperation Dilemma

If we can remove the confrontation dilemma, then the parties will have to interact on a common position, which is, there was no difference of interest in the position offered. However, they can face a collaboration dilemma, which is they but have a possibility to not to believe each other about commitment to the position.

● *Trust dilemma*

Party 1 have a trust dilemma of party 2 if party 1 is not sure that party 2 will commit of the position, in this condition party 1 can move to other position, or find another way to confince party 2.

● *Cooperation dilemma*

Party 1 have a cooperation dilemma of party 2 if party 1 is also tempted not to commit to the common position, maybe there is another better future that the common position; and if party 1 want to remove this dilemma then

party 1 can move to other position, or party 1 can confined party 2 that party 1 still commit with the common position.

Confrontation manager software [7] will be use to analyze the dilemmas in conflict or collaboration between stakeholder.

3. Methodology

In this research, we want to find each agent's attitude and statements that have the same interest on Citarum River. Therefore, we use qualitative methods approach in collecting data. [8] said that qualitative methods try to express uniqueness from everyone, group, society, and/or organization in daily life as a whole, detail and can be accounted scientifically. The type of qualitative method that used in this research is grounded theory, a systematic method in social science, which is using theory based on data that have been collected. Through this qualitative study five agents was identified *i.e.* Government, Public Enterprise, Business, NGO, and Community and the description of each agent can be shown in Table 1.

Table 1. General Description of Agent

No.	Name of Agent	General Description
1.	Government	Formulate policy, to control the environment in Citarum river basin and coordinate the interaction between agents. Government is a non-profit organization.
2.	Public Enterprise	BUMN and BUMD for meeting people's need, but profit oriented.
3.	Business	Profit oriented business (example: trading company)
4.	NGO	NGO have a lot interaction of government and become as a consultant for many kind programs for citarum's environment. NGO is a nonprofit institution.
5.	Community	People who live in Citarum area.

Each player and agent has a direct involvement of Citarum River, although the river's condition is getting worse because of extreme exploitation. Every agent has the same goals, which is to improve Citarum River into a better condition. To reach this goal, coordination is the most important thing to do by every agent, but unfortunately it is very hard to do. Every agent has their own priority that has to reach in every year until the conflict appear between agents.

Based on interviews with agents, we find that from each agent, there is a different and interest related to sustainability of Citarum River, and in the end it leads to conflict. There are many types of conflict, but according to the observation in this case, conflict that appears between agents is a realistic conflict. [3] in his book said that Lewis Coser grouped conflicts in two that is a realistic and nonrealistic conflict. Realistic conflict based on Lewis Coser is a conflict that can be happened because of a different and disagreement about how to achieve or objective about the goals that have to be achieved. In this conflict, we focused on a disagreement issue about the conflict object that has to be done by every agent. Conflict management methods that can be use are dialogue, persuasion, discussion, voting and negotiating. Interviews are used in this study and based on that we find options and threats from each agent that can be shown in Table 2.

Table 2. Option and Threat from each agent

Agent	Option and Threat
Business Sector	<ul style="list-style-type: none"> • stop damaging drainage • stop polluting Citarum
Community	<ul style="list-style-type: none"> • protest • stop illegal lodging • stop waste disposal to river
Government	<ul style="list-style-type: none"> • maintenance down stream river • give sanction to people • give sanction to business sector • Give real estate license
NGO	<ul style="list-style-type: none"> • protest
Public Enterprise	<ul style="list-style-type: none"> • regulate the waste disposal • reforestation

After the identification of option and threat from each agent, the analysis is continued with common reference frame analysis. Common reference frame was constructed in this study by using Confrontation Manager Software. It was

identified through observation and focus group discussion with the stake holders in Citarum River Basin conflict. Common Reference Frame in Citarum river basin conflict can be seen in Table 3 and 4 respectively before and after the period of 2009. Based on the options, we find that conflict in this case can be analyzed using confrontation manager software. In collecting data, we use two different steps, which is the data analysis based on real condition at a period before 2009 and after 2009.

4. Data Analysis

4.1. Period I Analysis (before 2009)

In period before 2009, people around Citarum River still neutral with Citarum River's condition. People in this period still feel freely throw the garbage in to the river. Government didn't give sanction to people around river whose damage the environment around the river in this period. In general, players are didn't really care and have a big attention about the environment condition around Citarum River. Common Reference frame in Citarum river basin conflict in the period before 2009 can be seen in Table 3.

Table 3. Common Reference Frame in Citarum River Basin Conflict before 2009

PARTICIPANT OPTION	THREAT	POSITION				
		BS	C	GOV	GREEN	PE
Business Sector			>>	>>	>>	>>
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes
Community		<<		>>	>>	>>
Protest	Y	Y/N	Y/N	Y/N	Y/N	Y/N
Stop illegal logging	No	No	No	Yes	Yes	Yes
Stop waste disposal to river	No	Y/N	No	Yes	Yes	Yes
Government		<<	>>		>>	>>
Maintenance down stream river	No	No	Yes	No	Yes	Yes
Give sanction to people	No	Yes	No	No	Yes	Yes
Give sanction to business sector	No	No	Yes	No	Yes	Yes
Give real estate license	Yes	Yes	No	Yes	No	No
NGO		<<	<<	<<		<<
Protest	Yes	No	Y/N	No	No	Yes
Public Enterprise		<<	>>	>>	>>	
Regulate the waste disposal	No	No	No	Yes	Yes	Yes
Reforestration	No	No	Y/N	Yes	Yes	Yes

From the common reference frame above it is found that there are 22 dilemmas from all agents. But in general, dilemmas in the period before 2009 is rejection dilemma which appears between :

- *Business sector with community.* Business sector prefer community's position to stop damaging drainage than its own position. Business sector agree with community's choice, but they need high budget to build a good drainage. That's why business sector still damage the drainage.
- *Business sector with government.* Business sector agree government's position to stop polluting Citarum River than its own position. Business sector wants to do the same action with government, but they do not enough budgets to build a qualified waste processing machine. That's why business sector still polluting the river.
- *Communities with Business sector.* Communities threaten to protest for bad condition in Citarum, but actually they prefer business sector's position. Communities realize that protest will not give a good progress to Citarum River.
- *Communities with government.* Communities prefer government position than its own position. Communities realize that illegal logging will harm them, but economic condition enforce communities to damage and make the forest become their farm.

- *Governments with Communities.* Governments prefer community's position than its own position. Governments realize there is a lot of things that they can do to make Citarum river into a better condition, one of it is to maintenance downstream river. Governments need a good cooperation with many parties, but it difficult to make.

4.2. Period II Analysis (after 2009)

In period after 2009, there is a significant change in attitude from some players. Communities in this period are become more aware and do protest, because the Citarum River's conditions become getting worst. Flood often come in rainy season and water's quality become worse. Based on that condition, government in this period makes some action to Citarum River such as cooperation with other party to build back the river into a better condition and also give a sanction to anyone who polluting the river. Like communities and government, NGO in this period also make some positive activity for the river.

While the result based on analysis for period after 2009 is can be seen in Table 4 below:

Table 4. Common Reference Frame in Citarum River Basin Conflict after 2009

PARTICIPANT OPTION	THREAT	POSITION				
		BS	C	GOV	GREEN	PE
<u>Business Sector</u>			>>	>>	>>	>>
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes
<u>Community</u>		<<		>>	>>	>>
Protest	Yes	No	Yes	No	Yes	No
Stop illegal logging	No	No	No	Yes	Yes	Yes
Stop waste disposal to river	No	Y/N	No	Yes	Yes	Yes
<u>Government</u>		<<	<<		>>	>>
Maintenance down stream river	No	No	Yes	Yes	Yes	Yes
Give sanction to people	No	Yes	No	No	Yes	Yes
Give sanction to business sector	No	Yes	Yes	Yes	Yes	Yes
Give real estate license	Yes	No	No	Yes	No	No
<u>NGO</u>		>>	<<	>>		>>
Protest	Yes	No	Yes	No	Yes	Yes
<u>Public Enterprise</u>		<<	>>	>>	>>	
Regulate the waste disposal	No	No	No	Yes	Yes	Yes
Reforestration	No	No	Y/N	Yes	Yes	Yes

From the common reference frame above it is found that there are 27 dilemmas from all agents. But in general, dilemmas in the period after 2009 are:

1. Rejection dilemma which appears between:

- Business sector with respect to community, government, public enterprise, and NGO. Business sector's rejection to community, government, and NGO position is not credible. Community, government, public enterprise, and NGO believes that business sector may prefer their position to the threatened future and business sector's position to not stop damaging drainage and stop polluting Citarum. But business sector don't have any choice because they need a high budget to build drainage system and IPAL for Citarum's waste disposal system. So that's why business sector still damage drainage and polluting Citarum.
- Government with business sector. Government's rejection to business sector position is not credible. Business sector believe that government may prefer their position to the threatened future and business sector's position (not stop

damaging drainage by build real estate). Government has a dilemma because business sector's position can gave benefit for government. So that's why government still give a real estate license to business sector.

2. Trust dilemma which appears between:
 - Communities with government. Communities doubted that government will commit with their agreement. Communities doubted that government will managed Citarum river with optimal.
3. Cooperation dilemma which appears between:
 - Government with community. Communities doubted that government would implement its commitments (maintenance downstream river and not give real estate license). Communities believe that government may prefer to not maintain downstream river seriously and give real estate license to business sector because there are many benefit for government from business sector. To eliminate this cooperation dilemma, governments convince communities that government serious to maintain downstream river and not give real estate license.
4. Positioning dilemma which appears between:
 - Government with community. Government actually prefers community's position to its own. Government actually prefers to not give a real estate license to business sector. Government realize that if business sector still damage the area around Citarum then the condition especially the impact for community is getting worst, but government still give a real estate license because in other way, business sector gave a lot of benefit to government through taxes.

5. Conclusion

The communities tend to be indifferent to the condition that occurs in Citarum in the period before 2009, but after 2009 the community has the courage to act more forcefully against the damage to the environment around the Citarum river due to damage in the impact on their daily lives. Some of the policies issued by the government for the maintenance of the Citarum river even more cause many problems. It can be seen from the increasing number of dilemmas that appear after period 2009. According to the purpose of this study, to see the dynamics of the conflict between the parties concerned in the Citarum in the period before and after the year 2009, based on common reference frame analysis that was done in two stages, it can be concluded that conflict can be avoided if each actor is capable of being rational, evidence, comprehensibility, emotional acceptability, and have a good coordination.

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Appendix B Proceedings of the World Congress on Engineering and Technology (CET) 2011

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Environmental Management Using Drama Theory

Case Study: Citarum River Basin Conflict, West Java, Indonesia

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Abstract— This research describes the dynamic of Citarum river basin conflict using drama theory approach. There are two phases in the conflict, first phase is the condition of Citarum conflict before the establishment of Integrated Water Resource Management (IWRM) and the second phase is the condition after the establishment of IWRM. IWRM is a process that gives priority in managing water, soil, and related resources in order to maximize the economic and social welfare in a pattern that does not compromise the sustainability of vital ecosystems. The result shows that the condition of Citarum conflict after the establishment of IWRM is worse than before the establishment of IWRM looked from the number of dilemmas. This research also provides the possible course of actions in order to reduce the dilemmas among stakeholders.

Keywords- Drama theory; Citarum Conflict; IWRM

I. INTRODUCTION

Citarum is the largest river in west java province; it is a nationally strategic river. The upper is located at mount Wayang (Bandung regency), citarum flow along 350 kilometers to end up in downstream at Tanjung (Karawang regency). Citarum river plays important role for socio-economic life, especially in West Java and Jakarta. Aside from being a source of drinking water, agricultural irrigation, fisheries, power plants, Citarum was also the main water supplier for industrial activities [1].

Today, the master plan of Citarum, titled Integrated Citarum Water Resources Management (IWRM) is in the process of implementation. A comprehensive approach of integrated watershed management is to demanding an open management that ensures the sustainability of coordination process between related institutions. In addition, to make the community participation looked important, start from planning, policy formulation, implementation and benefit

collection. On the other hand, the uncertainty from other agents' actions and how an agent will react to those actions consequently produce a result that couldn't be predicted based on each individual's act.

IWRM is a process that gives priority in managing water, soil, and related resources in order to maximize the economic and social welfare in a pattern that does not compromise the sustainability of vital ecosystems [2].

Ironically, watershed degradation, erosion and flooding that chronic up have not seen improved instead the opposite. The worsening flood condition in Citarum watershed makes a big question about the effectiveness of management of Citarum watershed over the years. Various efforts of technical approaches with financial support both from within and outside the country which have been done seems unsuccessful due to the efforts of other approaches such as social, law and politics that partially made by various parties.

This research discussed how the dilemmas involved in the creation of conflict and collaboration process and showed the dynamic process of the conflict. Drama theory using confrontation manager was used to model and analyze the Citarum watershed conflict. The time period was divided into two phases, namely before the establishment of Integrated Water Resources Management (IWRM) and after the establishment of IWRM.

II. METHODOLOGY

This research used survey focus group discussion method. Beside used literature study, in-depth interview also used to collect the data while confrontation manager used as the tool to analyze the dilemmas of this conflict.

Field data was mapped into 4 types. Front Stage-disclosed (FSD) was an interview approach to get the informants'

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identity, and used triangulation (Back Stage-disclosed, BSD) the interview continued to make the informants felt trust and secure. Front Stage-enclosed (FSE) was needed as ethics approach to make the informants open and honest, while Back Stage-enclosed (BSE) was a way to attract the informants' ideas and opinions both political and conflict scope.

There are two groups of dilemmas that occur in the process of conflict:

- **Confrontation Dilemma:** This dilemma occurs in conditions in which all parties do not have the same position (or at least there is one party that proposes a different position / not compatible with the other party's position), which causes those who have such a dilemma in applying credible not a threat, namely:
 - Threat dilemma (TrD)
 - Rejection dilemma (RD)
 - Positioning dilemma (PoD)
 - Persuasion dilemma (PD)
- **Collaboration Dilemma:** This dilemma occurs if they still have the possibility to not trust one another the commitment to the common position.
 - Trust dilemma (TR)
 - Cooperation dilemma (CD)

Based on focus group discussion, management conflict in Citarum watershed was involved multiple parties, namely the Clean Enterprises (CE), Community Alliances (CA), Controversial Enterprises (CoE), Government (G), Green Community (Gr), Green Government (GGr) and Public Enterprises (PE). Conflict of interest, lack of cooperation, bad communication and coordination among the parties become the source of problem of Citarum watershed more complex and worse.

From cultural theme analysis, findings are found and explained on Table I and II. Table I contains the operational definition of parties, while Table II contains operational definition of parties' options.

TABLE I. PARTIES (STAKEHOLDERS) IN CITARUM CONFLICT

Parties		
Clean Enterprise	CE	A party is a group of enterprises who has good opinion from other parties related with their performance
Community Alliances	CA	A party is a group of community organizations such as farmer alliance, woodlander alliance, merchant alliance, etc.
Controversial Enterprises	CoE	A party is a group of enterprises who has controversial opinion from other parties related with legality issue
Government	G	A Party who has authorities to make official policies, this party is no profit-oriented party
Government Green	GGr	A Party who declares their company as Green but in reality they work for Government
Green	Gr	A party is a group of Professional NGOs and Opposition NGOs, who do the activities based on certain professional capability.
Public Enterprises	PE	A party that consist of BUMN and BUMD who have responsibilities both serving public and gain profit for the company (profit-oriented party)

TABLE II. PARTIES AND OPTIONS

Options		
Clean Enterprise	CE	<i>Doing Discretionary Responsibility (CSR)</i> community relationship, good citizenship, corporate social responsibility completely
Community Alliances	CA	<i>Stop Seasonal Agriculture</i> Farmers do agriculture activities which are cropping seasonal plants such as vegetables, corn etc.
		<i>Anarchy Demonstration</i> They destroy building, public facilities, etc.
		<i>Conducting Government's Advice</i> Government held counseling related to flooding issue, environmental issue, and cleanliness issue frequently.
Controversial Enterprises	CoE	<i>Stop polluting Citarum River</i> There are many enterprises especially factories who are polluting Citarum river with tons of chemicals that can change the sex of fish, according to official data.
		<i>Stop Damaging Drainages</i> There are a lot of Enterprises, which are locating at city area built their office, mall, shop or factory without built good drainage.
		<i>Doing Legal Responsibility (CSR)</i> Legal Responsibility reflects enterprise responsibility to obey the laws that manage business activity.
Government	G	<i>Giving Sanction to Offenders</i> Offender here means someone/ company that offends public law
		<i>Coordinating among Agencies</i> Agencies today have no good communication each other, the situation triggering overlapping policies, internal conflict, and external conflict
		<i>Stop Permitting for Destructive Residential and Industry</i> They build regencies, villas, restaurants, hotels whereas those areas should be green areas.
		<i>Giving More Authorities for Green and Public Enterprises</i> There are limited authorities for Green and Public Enterprises to do their job
Government-Green	GGr	<i>Implementing Green's Programs</i> That name is made by politic organizations that still use "Green" in their company name but in reality, they didn't do anything for the community benefit.
Green	Gr	<i>Helping Government</i> So this option means that greens in Citarum not only as opposition organizations but also be professional organizations or government partner organizations in the same time.
		<i>Protest</i>
Public Enterprises	PE	<i>Proactive for Agency Sustainability</i>

III. RESULT AND DISCUSSION

TABLE III. MATRIX OF DILEMMA AND COMPATIBILITY PHASE 1

	CE	CA	CoE	G	GGr	Gr	PE
CE							
CA	RD						
CoE	RD	RD		CD	RD	RD, CD	RD
G	RD	TrD, RD, PD	TrD, RD, PD		TrD, RD	RD	PaD, RD
GGr		RD	RD	RD		RD	
Gr		RD	RD, TD	RD, TD	RD		RD
PE		RD	RD	RD		RD	

TABLE IV. MATRIX OF DILEMMA AND COMPATIBILITY PHASE 2

	CE	CA	CoE	G	GGr	Gr	PE
CE			RD				
CA			RD, CD, TD	PaD, CD, TD	RD		RD
CoE	RD, CD	RD, CD, TD		RD, CD, TD	RD, CD	RD, CD	RD, CD
G		PaD, RD, CA	TrD, RD, CoE		TrD	RD	RD
GGr		RD, TD	RD	TD		RD	RD
Gr			RD, TD	RD, TD	RD, TD		RD
PE	TrD	RD, TD	TrD, RD, TD	RD, TD	TrD, RD	TrD, RD	

From the result tables, we can see that the number of dilemma from phase 1 to phase 2 is increase. There is evidence that the establishment of IWRM does not make the condition of Citarum river basin conflict better, even getting worse.

According to U.S Agency for International Development [3] IWRM invited government, community, and other stakeholders to select among alternative of clean water utilization, and invites them to participated from planning to implementation where the stakeholders identified their need of water without destroying water resources and ecosystems.

At phase 1, community alliances don't have Cooperation Dilemma, but they have at phase 2. Cooperation dilemma at phase 2 is happen because the member of community alliance disappointed by the action of government and controversial enterprises. There are so many promises created by government and controversial to make Citarum better but the reality shows they don't do the best action to achieve that, community alliances are getting angry and they think that the best action is betray the government and controversial enterprises. Community alliance don't believe that IWRM can fix their dilemma, because they think IWRM is a powerless agency and work for government and private company not for them. Although the definition from USAID is maintain social, economic, and environmental goals as well as democratic, but in reality make the IWRM pragmatics.

Different from USAID, World Bank [4] said that IWRM perspective was assuring social, economic and environment dimensions as well as technical in management pattern and water resources development.

At phase 1, public enterprises only have Rejection dilemma, at phase 2 the dilemma is increase. Trust dilemma happen at phase 2, because other stakeholders (government, controversial enterprises, and community alliances) presume that the public enterprises performance are decline. For

example PLN (State Electricity Company), one of member of public enterprises, shows a decrease in company performance by occurrence of power outages either in rotation or sudden frequently. Those harm other stakeholders, especially the industries (enterprises) that have to get very large losses. Related with the definition from World Bank, IWRM have not implemented the technical aspects until now, the community alliances don't know how the dispose the waste from agricultural activity properly.

Otherwise, green reduce their dilemma to community alliance, at phase 1, green has rejection dilemma to community alliances, but at phase 2 they have not. It can be possible because the community feel much helped by the presence of green around them. Green is one of the front line is quite proactive in seeking improvements in the nature of knowledge and insight. Many of members of green are a member of local community, now the community considers that green is theirs.

The condition above reflects the definition of IWRM from Global Partnership [5] that IWRM defined as an approach process promoting and coordinating the development of water and land managed with source in a way to maximize the economic and social welfare in equilibrium with no ecosystem compromise.

Definition IWRM formulized by The Inter-American Development Bank (IADB) was a process to reduced conflict of water either quantitatively or qualitatively. From the definition, IWRM in IADB considered the needed of change in paradigm, from development to management, from a sectoral to an integrated approach [6].

After the establishment of IWRM, government eliminated their threat dilemma toward community alliance. Before the IWRM established, the community alliance always ignored the threat from government. The community alliance built residence near critical area of Citarum, also did illegal logging. After the establishment of IWRM, government showed their emotion to be firmer toward violation did by community alliances, and also did comprised. Soft approaches introduced to community alliance by made seminar of the dangerous of illegal logging etc. succeed made people aware that the threats from government were serious and they accepted the threats for their safety.

IWRM is a new paradigm of water containing the values of the common life of mankind, from the present generation to future generations, where water as the life pulse of the world, fulfilling the need for water for a person is a human right, so its management is not just based on the hydraulic mission but in perspective and dimensions; spiritual values, social, cultural, legal, political and economy and the preservation of environment in a sustainable manner. IWRM thus becomes the new rules in the governance inundated [7].

As the new rules of governance inundated, IWRM requires promotion, cooperation and awareness of all stakeholders both at international, national and local levels and community

groups, especially in the formulation of policies, rules, techniques of construction.

The process of IWRM should involve the participation of all stakeholders (government, community alliances, controversial enterprises, clean enterprises, green-government, green, and public enterprises) in identification, planning, implementation, operation and maintenance processes, must consider the preservation of ecological integrity of spatial analysis, to increase social welfare, economic growth, reduce conflicts both present to the future. So that IWRM will be a reference solving problems in a more comprehensive inundated.

IV. CONCLUSION AND SUGGESTION

From the results above we can conclude that in Citarum conflict using the same parties and same options, the dilemmas that occurred before the establishment of IWRM (Part 1) such 48 dilemmas did not significantly different with the dilemmas that occur after the establishment of IWRM (Part 2) such 57 dilemma. The additional number of dilemmas could be indicators that Citarum conflict in deteriorating condition which means the handler and the efforts of all parties to overcome the crisis of Citarum still has not found a bright spot.

Community alliances can do several actions to face cooperation dilemma toward government and controversial enterprises using positive emotion, do one or more of the following:

- Shows that the costs or difficulties Community Alliances would incur in carrying out these commitments are less, or less credible, than Controversial Enterprises and government suppose. If they do anarchy demonstration, harm the factory facilities, the company will be loss and possible job cuts would occur
- Show that the advantages they would gain from carrying them out are greater, or more credible, than Controversial Enterprises and government suppose.
- Show that they must inevitably carry them out.

To face it trust dilemma toward community alliances, government and controversial enterprises, public enterprises can show mistrustful or neutral emotions in its way of action

They then send messages to do one or both of the following:

- Show that the costs or difficulties to Community Alliances, government, and controversial enterprises of these defections from Public Enterprises' position are greater, or more credible, than Community Alliances suppose.
- Show that the advantages to Community Alliances, government, and controversial enterprises of sticking to Public Enterprises' position are greater, or more credible, than Community Alliances suppose

The increasing of dilemma make all stakeholders need to plan their possible of actions to reduce the dilemma. Clean enterprises can do conciliation or compromise to face rejection dilemma toward controversial enterprises if clean enterprises want to do positive emotion toward controversial enterprises. For example, they can do open discussion to frame the image of enterprises generally, because every time doing something bad, other stakeholders generalize it as enterprises activity, even clean enterprises do not do.

The Suggestions for further research are try an approach that reflects the reality condition by looking the dynamics of group formation. Unlike this research, the party can also be distinguished more specific because it could be different options and interest among the party itself.

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How Can Agent Learn Other Agent's Emotion in Dynamic Negotiation Process?

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Abstract— This study aims to construct an agent-based simulation of the dynamics of negotiation based on drama theory frame-work by incorporating emotion and learning. This model is able to show the evolution of a common reference and show the effect of agent's emotional states toward the number of dilemmas that will be produced in the final common reference frame. The constructed model suggests that positive agent's emotional states will be able to encourage collaboration among agents.

Keywords- agent-based simulation ; negotiation; drama theory; conflict resolution

I. INTRODUCTION

A conflict, from mere difference of opinion to deadly confrontations, is inevitable in human life. As an effort to resolve conflict, negotiation is a very common process in everyday life. This is why the negotiation process studied in various scientific fields such as economy, political science, psychology, organizational behavior, decision sciences, operations research and mathematics [1].

Negotiation in the real world (except in its most simple form) has some characteristics *i.e.*:

- Decentralized [1], parties in a negotiation can have different frames and strategy in seeking resolution of conflict.
- Involve communication among parties [1]. Decisions of negotiators are interlinked through communication processes that involve many different levels [2].
- Involve incomplete information [1], for example, a party cannot know for certain utilities from the other parties.
- In many cases, negotiation process in the real world

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involves repeated interaction with no well-structured sequences [1].

Negotiation process involves the emotions of each party. Emotion is an important device in structuring goals, values and preferences [3] and affects communication [2] in a negotiation.

Characteristics possessed a negotiation process reflect characteristics possessed by a complex system since:

- The elements involved in a negotiation process are heterogeneous and autonomous agents (parties).
- Agents involved a negotiation process are bounded rational they can have bias in information and may have a misperception toward the other agents.
- Communication process in a negotiation involves transmission of knowledge that will influence the behavior of its recipient.
- Negotiation is an iterative process. Such process involves feed-back loops that allows enable an agent to learn and revise his/her strategy. This makes the system (condition during the negotiation process in this case) evolve over time [4].
- In general, interactions in a negotiation process are non-linear in the sense of, for an action there are many possible outcomes that could be produced and, for an outcome there are many possible actions that may cause it.

Mostly, negotiation studies from social science field lean on descriptive dimension by identifying the factors involved in the negotiations while, the negotiation studies from mathematics and economics lean on prescriptive dimension by aiming to formalize the negotiation process so that optimal solution can be obtained [1]. In studying complex system, descriptive studies, especially those using verbal representation have weakness because it is hard for the researcher and the

reader to determine precisely the implication of the ideas being put forward [5]. In the other hand, although mathematical formulation can provide more precise description, many of the mathematical equations are too complicated to be analytically tractable [5]. The common solution is to make simplifications until the equations become solvable [5]. Unfortunately, sometimes these assumptions are implausible or oversimplified, and can make the resulted theories seriously misleading [1,5].

This study aims to construct an agent-based simulation of the dynamics of negotiation based on drama theory framework. Agents in the constructed simulation are equipped with emotions and ability to learn. The agent-based simulation is chosen because it can minimize the number of simplifications used by its ability to fully represents individuals and model bounded rational behavior while, drama theory is chosen because, it proposes an episodic model whereby situations unfold. This paper discusses the construction process of this agent-based simulation and early findings from the simulation results.

II. PROPOSED MODEL

This section discusses stages in the construction of agent-based simulation of the dynamics of negotiation based on drama theory. The discussion in this section is divided into several sections. The first sub-section discusses the basic assumptions and the modeling process of agent's option, position, preferences and threat. The second sub-section discusses the modeling process of the dilemmas faced by agents. The dilemmas discussed in this paper are restricted only to the confrontation dilemmas. The third sub section discusses the negotiation protocol among agents. This sub-section explains how to model emotions and how to integrate them into agents, how agent's emotion will dynamically evolve during the negotiation and finally, the learning mechanism in this simulation.

A. Modeling Agent's Options, Position and Threat

In drama theory there are a number of agents have options, positions, preferences and threats. Interaction among agents occurred under the common reference frame that is, the joint perception regarding the conflict that occurs. In this simulation, an agent is represented as a column in a common reference frame.

For each agent i , a number of options (O_{ki}) are defined and are represented as rows on a common reference frame. At each time step t , agent i has position to accept or to reject each its own option. Agent's position toward its own options will generate payoff (Vo_{ki}^t) for the given agent. Agent i 's payoff has two dimensions namely *accept dimension* and *reject dimension*. If agent i 's position is to accept option k , then agent i 's payoff in *accept dimension* is assigned as a (a real number between 51 to 100) and, agent i 's payoff in *reject dimension* is assigned as $(100 - a)$. The opposite rule applies if agent i position is to reject option k .

Each agent j ($j \neq i$), has position to accept, to reject or indifferent toward option k of agent i . Agent j 's position toward agent i 's options will generate payoff (Vpo_{kij}^t) for the

given agent. Agent j 's payoff has two dimensions namely *accept dimension* and *reject dimension*. If agent j 's position is to accept option k of agent i , then agent j 's payoff in *accept dimension* is assigned as a (a real number between 51 and 100) and, agent j 's payoff in *reject dimension* is assigned as $(100 - a)$. The opposite rule applies if agent j position is to reject option k of agent i . If agent j 's position is indifferent toward option k of agent i then agent j 's payoff in both dimensions are assigned as 50.

The total payoff obtained by agent i by adopting its own positions in each iteration t is calculated as follows:

$$Vp_i^t(p_i^t) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad (1)$$

Where:

m = number option and ($i \neq j$)

p_i^t = positions of agent i in iteration t

While, the total payoff obtained by agent i by adopting agent j 's positions in each iteration t is calculated as follows:

$$Vpp_i^t(p_j^t) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad (2)$$

Where:

m = number option and ($i \neq j$)

p_j^t = positions of agent j in iteration t

For all options, a set of threats is defined. The total payoff obtained by agent i by adopting threatened future in each iteration t is calculated as follows:

$$Vpt_i^t(T) = Vo_{ki}^t + \sum_m Vpo_{kij}^t \quad (3)$$

Where:

m = number option and ($i \neq j$)

T = treat

B. Modeling Agent's Dilemmas

In each iteration agent i 's dilemmas toward agent j are determined based on the payoff that will be obtained by agent i . There are two kinds of dilemmas that are considered in this research, i.e. rejection dilemma and persuasion dilemma [6]. Those dilemmas are defined as follow.

- If agent i 's payoff by adopting agent j 's position is greater than or equal to agent i 's payoff to adopt its own threat then, agent i has rejection dilemma toward agent j .
- If agent i 's payoff by adopting agent j 's position is less than or equal to agent i 's payoff to adopt its own threat then, agent j has persuasion dilemma toward agent i .

C. Negotiation Protocol

In this negotiation protocol, each agent is equipped with emotion that is modeled using PAD temperament model [7]. In this model, emotional state is constructed by three independent dimensions *i.e.* pleasure arousal and dominance. The formulation of party's emotional state is as follows [8].

$$Se_{ij}(r_p, r_a, r_d) = r_p \cdot (1 + r_a) - r_d \quad (4)$$

During the simulation agents will conduct negotiation for options with incompatible positions (*e.g.* agent *i* accept the option while agent *j* reject the option). The negotiation protocol in this research is constructed based on rational negotiation framework in which, agent *i* will offer certain amount of its payoff (s_{ij}) in order to shift agent *j*'s position toward agent *i*'s position. The potency of agent *i*'s offer to shift agent *j*'s position (OV_{ij}) is affected by agent *i*'s emotional state toward agent *j* (Se_{ij}), and agent *j*'s perception toward agent *i*'s offer (OV_{ji}) is affected by agent *j*'s emotion toward agent *i* (Se_{ji}).

$$OV_{ij} = Se_{ij} \times st_i + st_i \quad (5)$$

$$OV_{ji} = Se_{ji} \times OV_{ij} + OV_{ij} \quad (6)$$

Suppose agent *i*'s position is to accept option *k* and agent *j*'s position is to reject option *k*, then agent *i*'s payoff in accept dimension will then subtracted by OV_{ij} and agent *i*'s payoff in reject dimension added by OV_{ij} while, agent *j*'s payoff in accept dimension is added by OV_{ji} and agent *j*'s payoff in reject dimension is subtracted by OV_{ji} . Similar rule applies for the opposite condition.

Each time an offer from agent *i* is perceived by agent *j* agent *i* will compare the response of agent *j* with agent *j*'s response in the previous iteration. Then, party *i*'s emotion state toward party *j* will change according to the concept of Flow Model of Emotion [9] which then mapped into PAD dimensions.

TABLE I CHANGE IN AGENT I'S EMOTIONAL STATES

Agent <i>i</i> offer (compare to previous iteration)	Agent <i>j</i> perception (compare to previous iteration)	Change in agent <i>i</i> emotion state toward agent <i>j</i>		
		r_p	r_a	r_d
Higher	higher	+	+	+
Higher	lower	-	+	+
Lower	higher	+	+	-
Lower	lower	-	-	-

Through this negotiation process agents will learn to identify the emotional state that can produce the biggest shift

in position of other agents (best emotional state). Learning mechanism which is built in this study is based upon the assumption that each agent will revise his/her emotional state according to his/her experiences in the previous iterations. Each time agent *i* give an offer to agent *j*, agent *i* will record emotional state that he/she use and the shift resulted in agent *j*'s position. If in the current iteration the shift in agent *j*'s position is higher or equal to the shift in agent *j*'s position in the previous iteration then, agent *i* will revise his/her best emotional state according to his/her emotional state in the current iteration.

III. SIMULATION AND RESULTS

The simulation model in this study was constructed by using NetLogo version 4.1.2. Inputs for this simulation model are the number of agents, the number of options and positions of each agent. This simulation model will then show the evolution that occurred in the common reference frame, the number of dilemmas and the emotional state of each agent. In the common reference frame agent's position is coded by green square if the given agent accept an option, red square if the given agent reject an option and yellow square if the agent is indifferent. The simulation results obtained from the model are consistent for any combinations of number agents, number of options and agent's positions. For the ease of discussion, this paper only show one set of experiments using 5 agents, 12 options and agent's positions at the beginning of the simulation as follows:

OPTION	THREAT	POSITION				
		Agent1	Agent2	Agent3	Agent4	Agent5
Agent1			>>	>>	>>	>>
Option 1	No	No	Yes	Yes	Yes	Yes
Option 2	No	No	Yes	Yes	Yes	Yes
Agent2		<<		>>	>>	>>
Option 3	Yes	No	Y/N	No	Y/N	Y/N
Option 4	Yes	No	No	Yes	Yes	Yes
Option 5	Yes	Y/N	No	Yes	Yes	Yes
Agent3		<<	>>		>>	>>
Option 6	No	No	Yes	No	Yes	Yes
Option 7	Yes	Yes	No	No	Yes	Yes
Option 8	Yes	No	Yes	No	Yes	Yes
Option 9	No	Yes	No	Yes	No	No
Agent4		<<	<<	<<		<<
Option 10	Yes	No	Y/N	No	No	Yes
Agent5		<<	>>	>>	>>	
Option 11	No	No	No	Yes	Yes	Yes
Option 12	No	No	Y/N	Yes	Yes	Yes

Figure 1. Initial agent's position configuration

In the experiment process the simulation is run repeatedly. The results obtained in each simulation are then grouped into two, zero dilemma condition and non-zero dilemma condition. Interactions among parties that will lead to each condition are then analyzed.

A. Zero Dilemma Condition

In this study, a common reference frame is considered to have zero dilemmas if there are no confrontation dilemmas remain among agents, or in other words, all agent's position are compatible.

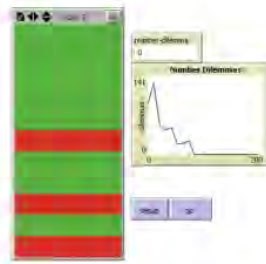


Figure 2. Output of the simulation result that show a zero dilemma condition

Based on the analysis from all runs, zero dilemma conditions will be achieved when emotional states of all agents tend to be positive toward the other agents. Figure 3 shows the cross tabulation of agent's emotional states towards other agents. In Figure 3 Se12 means emotional states of agent 1 toward agent 2, Se13 means emotional states of agent 1 toward agent 3, and so on.

Se11	Se12	Se13	Se14	Se15
0	1	1	0.98	1
Se21	Se22	Se23	Se24	Se25
1	0	1	1	1
Se31	Se32	Se33	Se34	Se35
1	1	0	0.99	1
Se41	Se42	Se43	Se44	Se45
1	1	0.99	0	0.99
Se51	Se52	Se53	Se54	Se55
1	0.99	1	1	0

Figure 3. Cross tabulation of agents emotional states in zero dilemma condition

By comparing all simulation results that produce zero dilemma condition, it can be concluded that the faster agents learn to achieve positive emotional states toward the other agents, then the faster are dilemmas are eliminated.

B. Non Zero Dilemma Condition

In this study, a common reference frame is considered to have non zero dilemmas if there are still any confrontation dilemmas remain among agents.

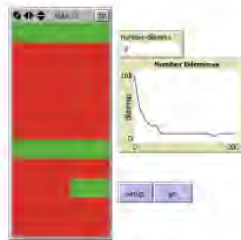


Figure 4. Output of the simulation result that show a non-zero dilemma condition

Based on the analysis from all runs, non-zero dilemma conditions will occur if there are some agents who have negative emotional states toward the other agents. Figure 5 shows the cross tabulation of agent's emotional states towards other agents.

Se11	Se12	Se13	Se14	Se15
0	0.97	0.72	0.87	0.97
Se21	Se22	Se23	Se24	Se25
-0.99	0	-0.41	0.78	0.67
Se31	Se32	Se33	Se34	Se35
0.01	1	0	-0.06	-0.42
Se41	Se42	Se43	Se44	Se45
0.22	0.69	-0.47	0	0.61
Se51	Se52	Se53	Se54	Se55
0.93	0.12	0.88	-0.46	0

Figure 5. Cross tabulation of agents emotional states in non-zero dilemma condition

IV. CONCLUSIONS AND FURTHER RESEARCH

Through this study an agent-based simulation of the dynamics of negotiation based on drama theory framework have been constructed. The simulation model has incorporate agent's emotions and learning ability into a negotiation protocol. This model is able to show the evolution of a common reference and show the effect of agent's emotional states toward the number of dilemmas that will be produced in the given common reference frame.

Model in this study is still need to be improved by integrating other dilemmas. The feasibility and accuracy of this simulation to represents the evolution real world conflict is also still need to be investigated.

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Rehearsing Initiatives to Facilitate Collaboration in Environmental Conflict

Case : Citarum River Basin Conflict

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Abstract— Citarum River is the longest river in West Java that due to industrialization, illegal logging and population explosion become one of the ten dirtiest rivers in the world. Efforts to restore the Citarum river condition hampered due to conflicts among stakeholders. This research purposed an agent-based simulation of negotiation process among stakeholders in Citarum River Basin conflict based on the drama theory framework. Agents in this simulation are equipped with emotional states and ability to learn. This paper discusses the general principle of the proposed model, steps to measure the accuracy of the model and the potential application of the proposed model to rehearse initiatives in the negotiation.

Keywords- agent-based simulation; drama theory; conflict resolution; rehearsing initiatives

I. INTRODUCTION

Citarum River is the longest river in West Java province. Citarum River Basin has an area of 6,080 km² across three provinces namely West Java, Banten and DKI Jakarta. In the past, Citarum River can provide the community needs such as clean water, power generation, fisheries, tourism and recreation. The number of people who depend on the Citarum River, making it one of the most strategic river in Indonesia. Unfortunately, the condition Citarum River now has changed completely

Since the industrialization in the 80s the Citarum River turned into industrial landfills. Currently there are about 500 textile factories that dispose their waste into the Citarum River, many of which are conducted without proper waste treatment. Citarum River condition is worsened by the population explosion in the upstream area. Increasing population has also increased the number of illegal logging and disposal of household waste. As a result, flood always occurs during the

rainy season due to sedimentation in downstream areas of rivers and increasing number of barren land.

Citarum River Basin Problem involves many stake holders through the literature study and focus group discussion, there are at least 33 stake holders in Citarum River Basin Conflict. These stakeholders have conflicting interest. Because of these conflicting interests, efforts to restore the condition of Citarum River become futile.

Emotion and learning are integral parts in a negotiation to achieve conflict resolution. This study aims to analyze the steps that can be carried out to resolve conflict in the Citarum River Basin by constructing a negotiation model that involves emotion and learning. This model was developed by combining drama theory and PAD emotional model. Results obtained from this model are intractable, therefore the agent-based simulation was used to identify the combination of action and reaction between the parties that can eliminate the dilemmas and encourage collaborations. The agent-based simulation is chosen because it can minimize the number of simplifications used by its ability to fully represents individuals and model bounded rational behavior while, drama theory is chosen because, it proposes an episodic model whereby situations unfold.

This paper gives an overview of Citarum river basin conflict and the general principles of the proposed model. In this paper, steps to measure model accuracy and the potential application of the proposed model are also discussed.

II. DRAMA THEORY OF CITARUM RIVER BASIN CONFLICT

Drama theory is a problem structuring method that uses a metaphor of drama to describe a complex confrontation situations [1]. Confrontation situation is a situation that involves many stakeholders with different interests and, each

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III. AGENT-BASED SIMULATION OF THE DYNAMICS OF NEGOTIATION

To build a simulation model of negotiation based on drama theory, the positions of each agent must be converted into scores [2]. Position scores represent pay-off that will be obtained by an agent when an option is accepted and when an option is rejected. Total payoff when an option is accepted and payoff when an option is rejected is 100. If an agents is indifferent toward an option then payoffs that will be obtained by that agent both when that option is accepted and when that option is rejected are assumed to be zero.

In this study an agent's threat is assumed as the most adverse position to other agents. For example, if agent i choose to adopt its option and the number of other agents who accept agent i 's option is greater than or equal to the number of other agents who reject agent i 's option then agent i 's threat is to reject its option and vise versa.

Using the above procedure dilemmas faced by all agents can be identified as the comparison of payoffs that will be obtained by an agent [2]. There are two kinds of dilemmas that are considered in this research, i.e. rejection dilemma and persuasion dilemma. Those dilemmas are defined as follow:

- If agent i 's payoff by adopting agent j 's position is greater than or equal to agent i 's payoff to adopt its own threat then, agent i has rejection dilemma toward agent j .
- If agent i 's payoff by adopting agent j 's position is less than or equal to agent i 's payoff to adopt its own threat then, agent j has persuasion dilemma toward agent i .

In this negotiation protocol, each agent is equipped with emotion that is modeled using PAD temperament model [3]. In this model, emotional state is constructed by three independent dimensions i.e. pleasure arousal and dominance. The formulation of party's emotional state is as follows [4].

$$Se_{ij}(r_p, r_a, r_d) = r_p \cdot (1 + r_a) - r_d \quad (1)$$

During the simulation agents will conduct negotiation for options with incompatible positions (e.g. agent i accept the option while agent j reject the option). The negotiation protocol in this research is constructed based on rational negotiation framework in which, agent i will offer certain amount of its payoff (s_0) in order to shift agent j 's position toward agent i 's position. The potency of agent i 's offer to shift agent j 's position (Ov_{ij}) is affected by agent i 's emotional state toward agent j (Se_{ij}), and agent j 's perception toward agent i 's offer (Ov_{ji}) is affected by agent j 's emotion toward agent i (Se_{ji}).

$$Ov_{ij} = Se_{ij} \times st_i + st_j \quad (2)$$

$$Ov_{ji} = Se_{ji} \times Ov_{ij} + Ov_{ij} \quad (3)$$

Suppose agent i 's position is to accept option k and agent j 's position is to reject option k , then agent i 's payoff in accept dimension will then subtracted by Ov_{ij} and agent i 's payoff in reject dimension added by Ov_{ij} while, agent j 's payoff in accept dimension is added by Ov_{ji} and agent j 's payoff in reject dimension is subtracted by Ov_{ji} . Similar rule applies for the opposite condition.

Each time an offer from agent i is perceived by agent j agent i will compare the response of agent j with agent j 's response in the previous iteration. Then, party i 's emotion state toward party j will change according to the concept of Flow Model of Emotion [5] which then mapped into PAD dimensions.

TABLE III. CHANGE IN AGENT i 'S EMOTIONAL STATES

Agent i offer (compare to previous iteration)	Agent j perception (compare to previous iteration)	Change in agent i emotion state toward agent j		
		r_p	r_a	r_d
Higher	higher	+	+	+
Higher	lower	-	+	+
Lower	higher	+	+	-
Lower	lower	-	-	-

Through this negotiation process agents will learn to identify the emotional state that can produce the biggest shift in position of other agents (best emotional state). Learning mechanism which is built in this study is based upon the assumption that each agent will revise his/her emotional state according to his/her experiences in the previous iterations. Each time agent i give an offer to agent j , agent i will record emotional state that he/she use and the shift resulted in agent j 's position. If in the current iteration the shift in agent j 's position is higher or equal to the shift in agent j 's position in the previous iteration then, agent i will revise his/her best emotional state according to his/her emotional state in the current iteration.

To measure how close the simulation model can describe the dynamics of conflict in the real world, a similarity variable is defined. This variable indicates the ratio between the number of position predicted by simulation which is similar to position on the common reference frame after 2009, and the total option available.

IV. EXPERIMENTS AND DISCUSSION

In our previous study, some behavior of the proposed mechanism has been discussed. This behavior such as:

- The dilemmas among parties can be eliminated if all parties able to learn to use positive emotional state toward the other agents.
- The dilemmas are still possible to be eliminated although there are some parties who use negative

stakeholders has different position for each interest. Based on the literature study and field work, there are 33 parties (agents) who participate in Citarum River Basin conflict. These stake holders can be grouped into five, as described in Table I.

TABLE I. GROUP OF STAKE HOLDER IN CITARUM RIVER BASIN CONFLICT

No.	Name of Agent	General Description
1.	Government	Formulate policy, to control the environment in Citarum river basin and coordinate the interaction between agents. Government is a non-profit organization.
2.	Public Enterprise	State Owned Enterprise and Province Owned Enterprise for meeting people's need, but profit oriented.
3.	Business	Profit oriented business (example: trading company)
4.	NGO	NGO have a lot interaction of government and become as a consultant for many kind programs for citarum's environment. NGO is a nonprofit institution.
5.	Community	People who live in Citarum area.

In drama theory each agent is assumed to have options or decision that can be chosen. Through focus group discussion with the stake holders in Citarum river Basin Conflict, options owned by each agent can be identified. Table II, describe options owned by each agent in Citarum River Basin Conflict.

TABLE II. OPTION OF EACH AGENT IN CITARUM RIVER BASIN CONFLICT

Agent	Options
Business Sector	<ul style="list-style-type: none"> stop damaging drainage stop polluting Citarum
Community	<ul style="list-style-type: none"> protest stop illegal lodging stop waste disposal to river
Government	<ul style="list-style-type: none"> maintenance down stream river give sanction to people give sanction to business sector give real estate license
NGO	<ul style="list-style-type: none"> protest
Public Enterprise	<ul style="list-style-type: none"> regulate the waste disposal reforestation

Interaction among agents produces a common reference frame, a view agreed by all agents about the problems they

face [1]. A common reference frame contains options owned by each agent, positions (whether an agent agree or disagree toward an option), threat (fall back option) and options preferences of each agent. In order to measure how close the model can represent the dynamics of conflict in the real world, the common reference frame in this research was taken at two different time frames *i.e.* before 2009 and after 2009. Through focus group discussion with the stake holders in Citarum river Basin Conflict, common reference frame for both time frames can be identified as follows.

AGENTS OPTION	THREAT	POSITION					
		BS	C	G	NGO	PE	
Business Sector			>>	>>	>>	>>	
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes	
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes	
Community		<<		>>	>>	>>	
Protest	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	
Stop illegal logging	Yes	No	No	Yes	Yes	Yes	
Stop waste disposal to river	Yes	Y/N	No	Yes	Yes	Yes	
Government		<<	>>		>>	>>	
Maintenance down stream river	No	No	Yes	No	Yes	Yes	
Give sanction to people	Yes	Yes	No	No	Yes	Yes	
Give sanction to business sector	Yes	No	Yes	No	Yes	Yes	
Give real estate license	No	Yes	No	Yes	No	No	
NGO		<<	<<	<<		<<	
Protest	Yes	No	Y/N	No	No	Yes	
Public Enterprise		<<	>>	>>	>>		
Regulate the waste disposal	No	No	No	Yes	Yes	Yes	
Reforestation	No	No	Y/N	Yes	Yes	Yes	

Figure 1. Common reference frame in Citarum river Basin Conflict before 2009

PARTICIPANT OPTION	THREAT	POSITION					
		BS	C	G	LSM	PE	
Business Sector			>>	>>	>>	>>	
Stop damaging drainage	No	No	Yes	Yes	Yes	Yes	
Stop polluting Citarum	No	No	Yes	Yes	Yes	Yes	
Community		<<		>>	>>	>>	
Protest	Yes	No	Yes	No	Yes	No	
Stop illegal lodging	No	No	No	Yes	Yes	Yes	
Stop waste disposal to river	No	Y/N	No	Yes	Yes	Yes	
Government		<<	<<		>>	>>	
Maintenance down stream river	No	No	Yes	Yes	Yes	Yes	
Give sanction to people	Yes	Yes	No	No	Yes	Yes	
Give sanction to business sector	No	Yes	Yes	Yes	Yes	Yes	
Give real estate license	Yes	No	No	Yes	No	No	
LSM		>>	<<	>>		>>	
Protest	Yes	No	Yes	No	Yes	Yes	
Public Enterprise		<<	>>	>>	>>		
Regulate the waste disposal	No	No	No	Yes	Yes	Yes	
Reforestation	No	No	Y/N	Yes	Yes	Yes	

Figure 2. Common reference frame in Citarum river Basin Conflict after 2009

emotional state. One kind of strategy in this condition is by forming an alliance.

- This alliance is easier to be initiated by party who has positive emotional state toward the other parties. After the initiator successfully creates common position with several other parties, they will be able to force party who has negative emotional state to accept their position.

The experiment in the current study aims to measure the accuracy of the proposed simulation and identify actions that can be carried out by agents in the real world to eliminate the existing dilemmas.

To measure the accuracy of the simulation model simulation, the simulation process is run repeatedly. Based on simulation data that are obtained the largest similarity value is 36.36%. This means that the dynamics that occur during the simulation process has experienced a phase in which 20 agent's positions in the simulation are similar to agent's position in real common reference frame after 2009. Of course, since the simulation model contains processes with random nature, the possibility of this outcome is small.

To identify the combination of action and reaction between the parties that can eliminate the dilemmas and encourage collaborations the simulation data are tabulated and described as a tree as for example follows.

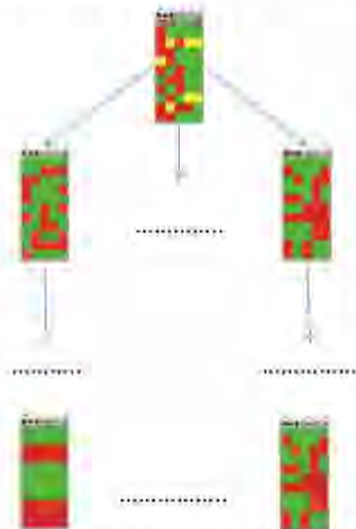


Figure 3. The tree of predicted dynamics of the Citarum river Basin Conflict

This tree can help to illustrate the possible scenarios that can be chosen in a particular phase of the conflict. For example, in one of the experiment, NGO has incompatible position toward Business sector, Community and Government in term of Government option to give strict penalties for community. In this case, NGO has relatively positive

emotional condition toward the other agent. In the second round of negotiation in this experiment, NGO is able to give Business Sector sufficient bargain such that, they change their position from reject to adopt. Unfortunately, NGO is still unable to convince Community and Government to change their position. In the third round of the negotiation Business Sector try to convince Government and Community to change their position to adopt (the new Business Sector position after negotiation with NGO). In this case Business Sector is able to convince Community to change their position to indifferent. In the next iteration, NGO successfully conduct negotiation with Government such that, their rejecting payoff decreases significantly. After that, Business Sector tries to convince government again. This time Business Sector is able to convince governments such that, in the final condition their position change to adopt.

V. CONCLUSIONS AND FURTHER RESEARCH

In this research an agent-based simulation of negotiation process among stakeholders in Citarum River Basin conflict based on the drama theory framework has proposed. Agents in this simulation are equipped with emotional states and ability to learn.

This model accuracy is measured through experiments by comparing the dynamics of common reference frame in the simulation with the common reference frame from the real world that was obtained by using qualitative study. Based on this measurement, the accuracy of this model is still can be improved by reducing the randomness in the simulation, for example by using real agent's payoff parameter that can be gathered by survey.

Although the current model has low accuracy, this model is able to show the evolution of a common reference and illustrate the possible scenarios that can be chosen in a particular phase of the conflict. Using this simulation the dynamics during the negotiation and possible outcomes of the negotiation can be analyzed therefore prescription for the decision maker can be proposed.

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